an international monthly

THE Petroleum Engineer

Combined Edition

Drilling and Producing | Refining and Gas Processing | Oil and Gas Pipelining

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Nordstrom MUDLINE VALVES

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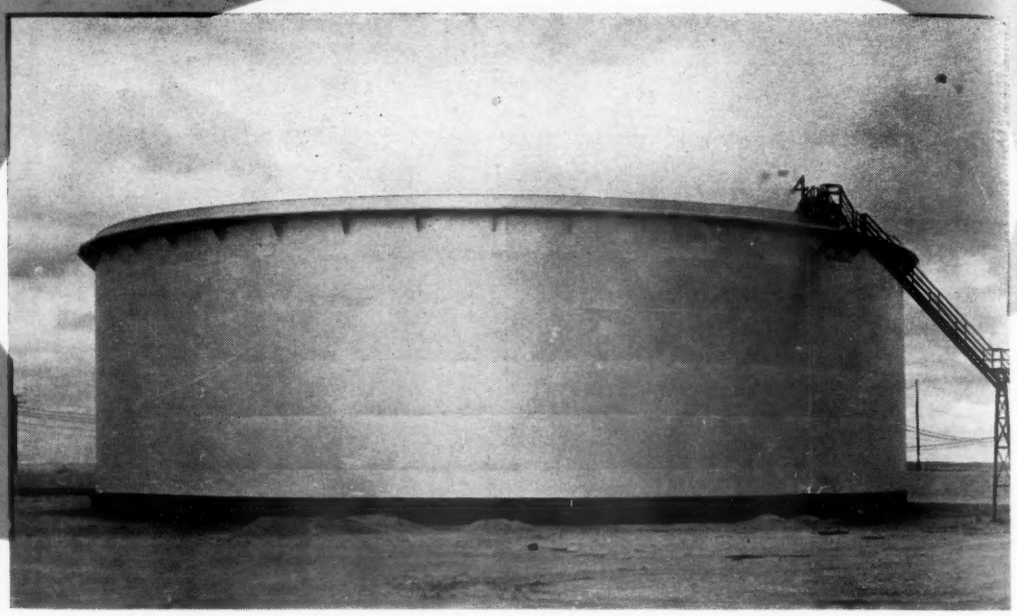
MARCH 1951

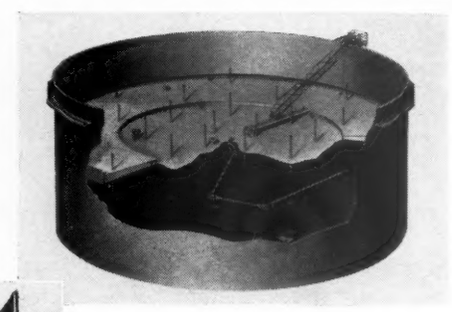
Why does THIS tank store gasoline...

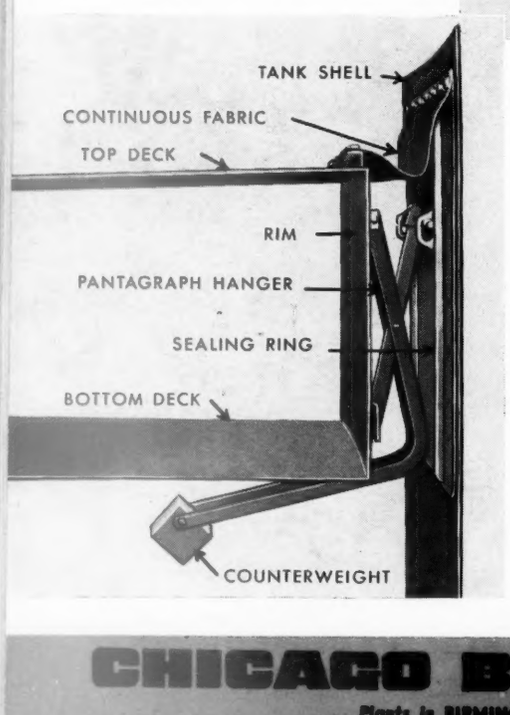


with greater safety . . . less evaporation loss?

ABOVE: *150,000-bbl. tank equipped with a Horton PONTOON Roof at a refinery in Venezuela. It is used to store motor gasoline.*

RIGHT: *Cutaway view showing how the PONTOON Roof floats directly on the liquid — a feature that decreases evaporation losses, reduces the fire hazard and cuts down corrosion of roof and tank plates.*





LEFT: *This is the Horton seal that is used to close the space between the deck of a Horton PONTOON Floating Roof and the tank shell. It is the best device ever invented for preventing the escape of vapor around the edge of a floating roof. The high efficiency of this seal not only cuts down evaporation losses —it also reduces the fire hazard because it makes certain that an inflammable mixture of vapor and air will not persist above the roof.*

THE REASON is because the tank is equipp with a Horton PONTOON ROOF—an outstandi type of floating roof which reduces the fire haza and cuts down all types of evaporation losses fr flat-bottom tanks storing gasoline, crude oil a similar volatile liquids.

There is no vapor space in a tank equipped w the PONTOON Roof because it floats directly on t liquid. The roof eliminates the air necessary to su port combustion and thus reduces the fire haza

Evaporation losses due to *breathing* are prevent because there is no air-vapor mixture under the r to expand as the temperature rises. *Filling* losses a eliminated since there are no vapors under the r to be displaced by incoming liquid. *Boiling* los are reduced as the pontoon section of the roof p vides air space insulation for over half the ar If, however, some boiling of liquid should occ the vapors are trapped beneath the flexible cen section of the roof due to the bottom of the ponto being sloped toward the center. The collected vap lift the center portion of the deck and furnish in lation which reduces further boiling.

The Horton PONTOON Roof can be installed new or existing tanks which are 60 ft. in diam. larger. It is recommended especially for tanks fil and emptied frequently, tanks in blending serv and tanks storing corrosive products. Write nearest office for full details about this efficient t of Horton Floating Roof.

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The Petroleum Engineer

COMBINED EDITION

• Drilling and Producing • Refining and Gas Processing • Oil and Gas Pipelining

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the Course of OIL

Why Tamper with Depletion Allowance?

As in any other kind of business, depletion is a deductible item from income in the production of oil and gas. It is comprised of two parts, tangible drilling costs and intangible drilling costs, and in that respect differs from ordinary depletion for income tax purposes. Ordinary depreciation may be taken on tangible drilling costs. In the depreciation of intangible costs, however, the oil producer has an option. He may charge these off 100 per cent in the year incurred or they may be included in capital costs that are returned through percentage depletion deduction. But no matter what method is adopted by the producer, the deduction on intangible drilling costs is a *depreciation* deduction. These deductions have nothing to do with percentage depletion, even though depreciation deduction may be recoverable through the percentage depletion deduction.

When the producer sells his oil, a capital asset, he has the same right as any business man selling a product, to deduct the cost of the oil sold in computing his taxable income. The actual cost of petroleum sold is difficult to arrive at, so Congress (in 1926) devised the percentage depletion deduction as a reasonably accurate method, based on extensive experience data, for computing the cost of petroleum sold. That, in brief, is the story behind the percentage depletion deduction.

The fact that the whole economy of the petroleum-producing industry is so geared to the intangible drilling costs and percentage depletion deductions means that any reduction in those deductions would lead to a reduction in drilling activity and a consequent slow-down in the discovery of new petroleum reserves. Many independent producers would be put out of business, the oil-producing states would suffer, and higher prices of petroleum products to the public would eventually result. It would be a crippling blow to the petroleum industry and would tend to concentrate ownership in a relatively few oil companies.

When Congress passed the percentage depletion deduction, one of the main objectives was that of insuring the maintenance of an adequate supply of oil. Through the years and despite violent price fluctuations the soundness of the deduction has been demonstrated and the mature judgment of Congress in passing the percentage depletion vindicated. A change in the depletion allowance should not be made without good proof that it is without sound basis in law and in fact and that it is not in opposition to the national interest. In view of the fact that the oil industry, because of the grave international situation, has been called upon to increase the capacity of its producing, refining, and transportation facilities to take care of an additional daily production of one million barrels of oil, it is no time to meddle with the depletion allowance. To do so, could seriously cripple a basic industry so essential to the national security. The risk is great. Can we afford it?—K. C. S.

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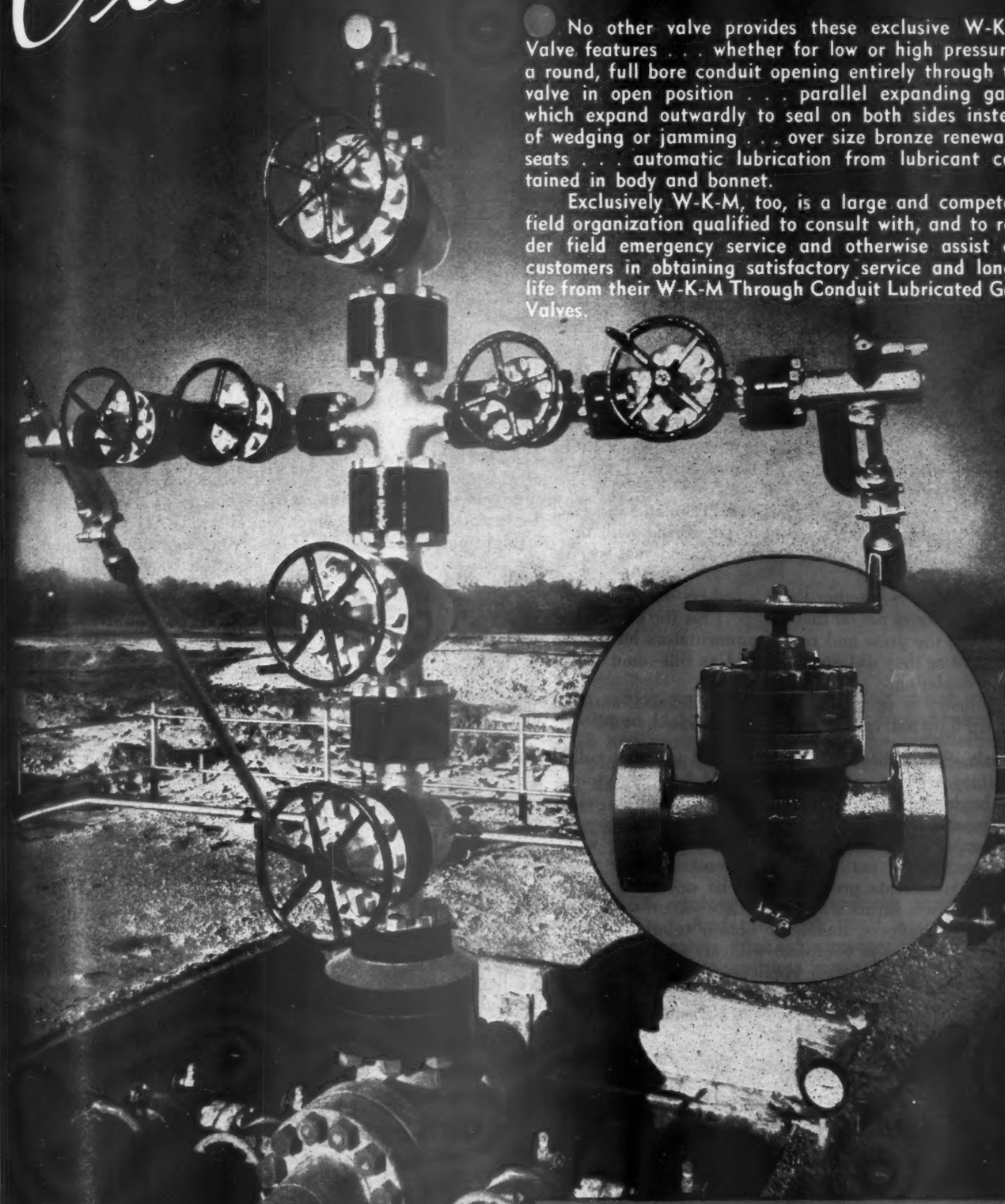

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Scanning WASHINGTON'S OIL HORIZON

By MILBURN PETTY

WASHINGTON—The military's request for 1,000,000 bbl daily expansion in the industry's capacity to produce, refine, and transport petroleum ties in directly with many pending issues such as depletion, tidelands, and materials.

This was emphasized by Dr. R. E. Wilson (Indiana Standard) who heads the National Petroleum Council's committee studying ways and means of achieving this expansion. If this goal is to be attained, Dr. Wilson said, "the climate within which the industry has heretofore met its great responsibilities to the government and the public must be maintained. Among such factors are the continuance of long standing tax provisions on depletion and intangible drilling expenditures," he added.

Settlement of the tidelands dispute so that offshore drilling operations may be resumed was another factor cited by Wilson's committee. Also there must be additional storage for heating oils if refinery operations are to continue the year round at the recent high levels.

▸ **Depletion.** Treasury has again recommended that the oil and gas depletion allowance be reduced from 27½ per cent to 15 per cent but without using any inflammatory adjectives. In fact, it was just about the minimum that could have reasonably been expected from the Truman Administration after last year's all-out attack.

There are signs that some of President Truman's closest advisers have urged him to go slow in tampering with the depletion allowance lest drilling be discouraged just when most needed.

The big question is whether these members of Truman's inner circle will stand pat on their support for the depletion allowance when the press and radio commentators let loose their onslaught as they did on the Kerr Gas Bill—and may do again on depletion.

So the industry is preparing a vigorous defense, anticipating a hard fight and taking nothing for granted.

▸ **Materials.** Steel mills have been directed to begin rolling oil country tubular goods at the rate of 1,890,000 tons per year, beginning April 1. This output, however, will flow into the normal channels of trade during the second quarter because the PAD-NPA allocations program will not begin functioning until July 1, at least. But the two emergency requirements programs will be operating very shortly. Application forms will be available soon.

Oil and gas producers, unable to obtain tubular goods from regular suppliers to complete wildcats of field wells, will apply to PAD and, if their applications are approved, they will be entitled to use a "Defense Order" rating to obtain these materials from the 5 per cent set aside provided for this purpose.

Also, operators in all branches of the petroleum industry, needing materials for maintenance, repairs and operating requirements, will be allowed to use the "DO" rating without applying to PAD on small orders.

▸ **Prices.** The oil price division of Office of Price Stabilization—called OPS, not OPA, this time—is now working up a series of orders that will provide "yardsticks" for relieving inequities that developed after the price freeze of last December.

OPS now plans to have separate orders for crude oil, for refined products, for lubricating oils and greases, for asphalt, and for retail prices. These will be mostly general rules, definitions, exemptions, etc., such as in the OPA orders, which are serving as patterns. When completed they will be tried out on the industry advisory committees now being set up.

▸ **Tankers.** U. S. Maritime Administration reports that practically all the American flag tanker owners have volunteered to participate in the "pool" to supply military requirements on a pro rata basis. Rates have been set at 25 per cent above the U. S. Maritime Commission rate of World War II for ships of 14,000 DWT and over; 40 per cent above USMC for those between 9000 and 14,000 DWT; and at individually-fixed rates for those in the 6000 to 9000 DWT group.

▸ **Fuels Study.** Four prominent oil men were among the experts announced as participants in the roundtable discussion of fuels policies, March 7, 8 and 9, sponsored by Chairman O'Mahoney of the Senate Interior Committee. They are A. Jacobsen (Amerada), Dr. R. E. Wilson (Indiana Standard), L. F. McCollum (Conoco) and B. A. Hardey, past president of the IPAA. Questions posed by O'Mahoney range from the advisability of a stripper well subsidy to stockpiling, offshore development, and methods of collecting data on petroleum reserves.

▸ **TEL.** Junking of PAD's proposed octane ceilings order was primarily due to the radically changed situation resulting from stepped-up military requirements of tetraethyl lead for aviation gasoline, which convinced PAD that only a straight-percentage cut in TEL supplies to refiners could do the job. But the unrelenting opposition by Sun Oil, Esso Standard, and others was a factor in slowing down PAD's issuance of the octane ceiling order.

The proposal, as it now stands, would allow each refiner a basic allotment of either a million pounds of TEL or his 1950 consumption, whichever was the smaller. A refiner using more than 1,000,000 lb would also be allowed 80 per cent of the difference between that figure and his actual consumption last year. There would be provisions for hardship cases. If this plan does not conserve enough TEL, it may be necessary to impose octane ceilings, too.

▸ **Tidelands.** Need for developing offshore reserves likely will bring quick action on Senator O'Mahoney's bill providing for the issuance of federal oil and gas leases on the so-called tidelands areas, which is backed by the offshore operators as well as the federal government.

On the House side, the supporters of quitclaim legislation—to restore these lands to state ownership—are dying hard. Their strategy may be to push through the quitclaimer so that they would be in a good trading position when the Senate and House conferees meet to iron out differences between the two bills.

During the Senate hearings, U. S. Solicitor Perlman stated flatly that neither Congress nor the President could surrender any part of the national sovereignty, one aspect of which, he said, is the federal government's paramount powers and full dominion over oil deposits in the submerged coastal lands.

"It is doubtful," Perlman added, "that Congress could quitclaim—in absolute, fee simple title—any portion of the submerged lands below the low-water mark."

The most that Congress could do, according to Perlman, is to authorize the states to act as "agents" for the federal government in managing these lands. What effect Perlman's statement will have on the states-rights congressmen, remains to be seen. But he may have given them some ideas.

. . . "to your order"

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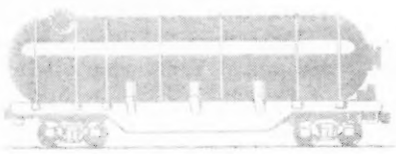

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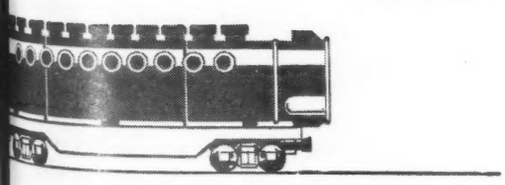

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HIGHLIGHTS IN OILDOM

NEW TAX PROPOSALS

The over-burdened petroleum industry may soon have another cross to bear atop its tax-bent shoulders. Four big tax raises are now proposed by Washington against the petroleum industry, and include: (1) a cut in the percentage depletion provision; (2) an increase of the present federal gasoline tax, now 1.5 cents, to 3 cents; (3) increase of the present tax on oil "appliances", now 10 per cent, to 25 per cent, and (4) increases of 8 percentage points in the corporate tax rate schedule, affecting all businesses in the petroleum industry.

SUN AIDS OHIO GAS SUPPLY

Sun Oil Company aided the Ohio Fuel Gas Company in Toledo, Ohio, to relieve gas shortages during the recent cold wave. Sun is able to do this by shifting to the use of heavy fuel oil in heating boilers at its Toledo refinery, thus making available for the heating of homes gas ordinarily used for this purpose. Sun made available a minimum of 2,500,000 cu ft of refinery gas per day.

WINTER INTERRUPTS DRILLING

Sub-zero weather held up drilling in Kansas and other areas where temperatures dropped steadily for a week. Quite a few tests were closed down for several days, and testing was held up because of the temperatures. As a result no new discovery wells were listed during a seven-day period while old man winter was giving out with the cold blasts.

EGYPTIAN CANAL RESTRICTIONS

Norway has joined several other countries in asking Egypt to lift the restrictions that have long hampered international traffic, especially oil, through the Suez Canal. As a result, the Egyptian Acting Foreign Minister has promised that Egypt will examine the causes of complaint, but declares she will continue to insist on her absolute control of the canal. The trouble, which began in 1948, flared up again when the Egyptians attempted to compel tanker masters to obtain Egyptian consular certificates to the effect that oil unloaded from their ships would be consumed in the country where it was unloaded, and subsequent orders that any ship that had visited an Israeli port after mid-June, 1950, should be refused fuel and victualling in any Egyptian port.

MINIMUM GAS PRICE

Although executive members of the Texas Independent Producers and Royalty Owners Association have pledged themselves to work toward improving the natural gas situation in the state, they have made no direct commitment toward sponsoring legislative action aimed at establishing a minimum price for the gas in Texas. Such a measure is now before the Legislature. It would fix a 10 cents per 1000 cu ft minimum. The committee named R. L. Foree, Dallas, to head up a committee to study all phases of the price problem and meet with the Railroad Commission to determine the agency's powers.

MARSHALL AID IN ENGLAND

A total of $2694 million in Marshall aid has been used for petroleum and refinery projects in the United Kingdom, The Petroleum Times reported. With the suspension of Marshall aid on January 1, a detailed account of the slightly more than 10 per cent of all Marshall aid allotted to Britain was set up as follows:

	$million
Oil products from U. S. A.	97
Oil products from other countries	166
Total oil products	263
Shell Haven refinery, ECA dollars	2.5
Llandarcy refinery, ECA dollars	7.2
Total	272.7

"U. S. RESOURCES LOW"—*Chapman*

The U. S. has been using its natural resources so rapidly that "the bottom of the barrel has nearly been reached", Secretary of the Interior Oscar L. Chapman stated in an annual report for the fiscal year ended last June 30. He said the nation has dug deep into its mineral deposits, drained off much of its petroleum, and depleted many of its forests. The Interior Department is giving special attention to programs that will make the best use of the resources, he said. In an effort to get oil from other sources department experts are "forging a research program to supply the scientific, engineering, and economic information required for the production of synthetic liquid and gaseous fuels from our abundant reserves of oil shale and coal," he concluded.

SEVERANCE TAX INCREASE

A bill to double Arkansas' severance tax on oil and natural gas has been introduced before the House of Representatives of the 1951 Arkansas legislature. The measure is estimated to increase state revenues more than $3,000,000 annually. The present severance tax rate on oil is 4 per cent of the market value at the point of severance. The proposed bill would increase the tax on oil to 8 per cent and on natural gas from 3/20-cent to 3/10-cent per 1000 cu ft.

DEPLETION ALLOWANCES AGAIN

The military's plea for 50,000 new wells this year was followed by President Truman's renewed request for closing the alleged loopholes in the oil tax structure. Without the depletion allowances, several oil men have pointed out to President Truman, independent operators, in particular, will not have the capital to finance such a huge exploration and development program. Secretary Chapman told members attending a National Petroleum Council meeting that he had presented the industry's case as best he could.

VENEZUELAN OIL RESERVE

More than 8 billion barrels is the amount of Venezuelan oil reserves as of December 1950, according to Dr. Antonio Martin Araujo, newly appointed ambassador to the U. S. He said Venezuela's daily oil production has reached 1,600,000 bbl, and if necessary, can be increased to 2,000,000. Araujo added that the U. S. is importing about 43 per cent of Venezuela's total oil output. Of the total foreign investment, about 1⅓ billion represents American investment and the rest British.

STORAGE FACILITIES INADEQUATE

Chicago is feeling the effects of lack of storage space for fuel oil. During the recent cold spell, Standard Oil Company (Indiana) restricted deliveries of fuel oil into that area because of transportation difficulties, brought on by the switchmen's strike. Frozen rivers curtailed barge movements and trucks had difficulty running because of highway conditions. Customers who have been depending on tank car deliveries were out of luck, and many businesses had to close down because of lack of heating fuel. There is no shortage of supply in the country.

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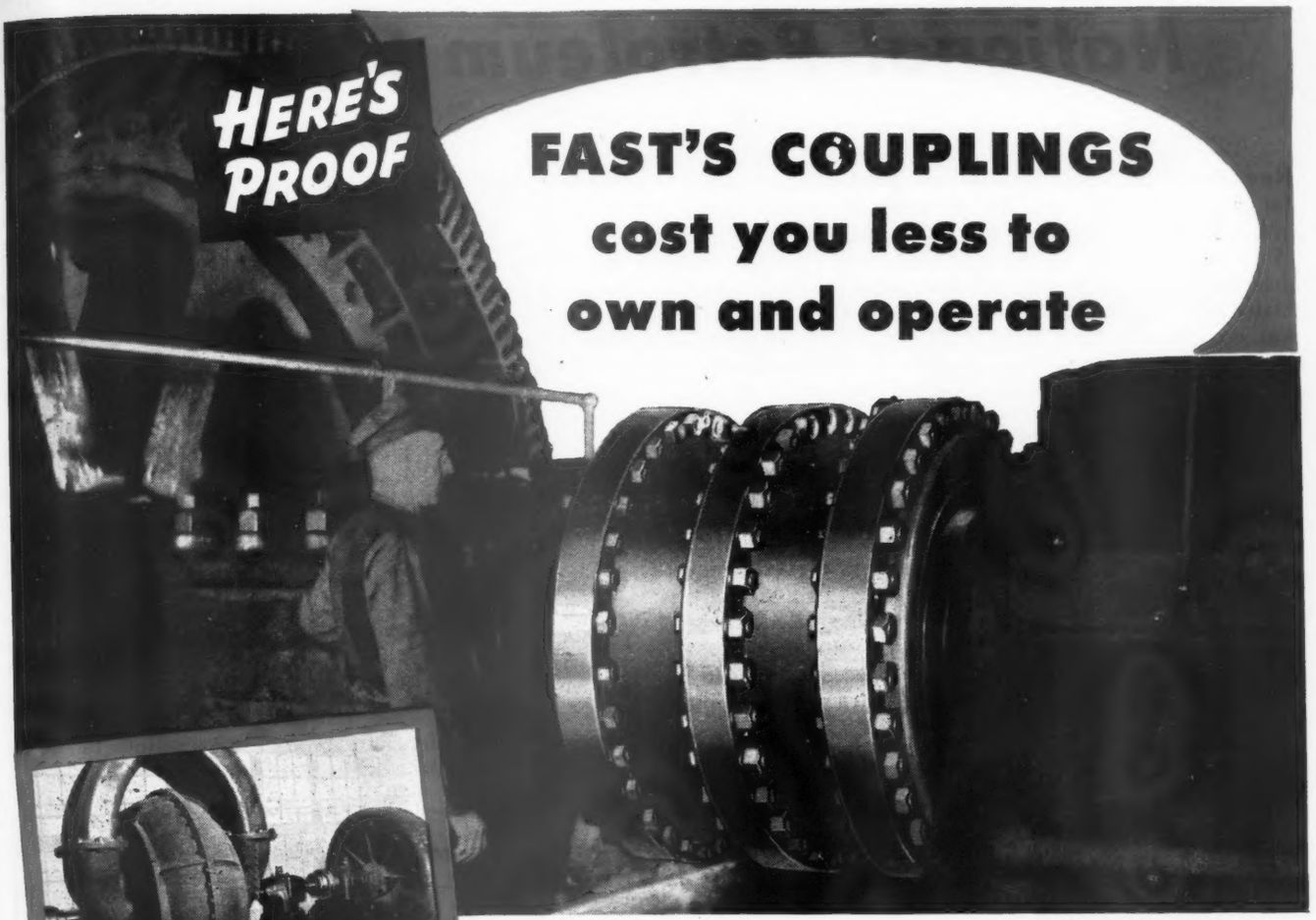

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INDUSTRY'S STANDARD FOR 31 YEARS

National Petroleum Situation

By H. J. STRUTH*

New demand peak. Demand for petroleum products in January registered a new all-time peak. Demand for all oils averaged about 7,763,000 bbl daily, marking an increase of 18 per cent over a year ago. Preliminary data indicates that domestic and foreign markets supplied by the United States are consuming about 1,200,000 bbl a day more than was consumed a year ago. Domestic requirements of the United States are more than a million barrels greater than a year ago, on a daily average basis.

Supply considerations. While the petroleum industry is doing a remarkable job in providing expanding supplies to meet the constantly growing demand, the job is being made more difficult because of political entanglements. Considerations of urgent importance to the oil supply outlook call for immediate action in the resumption of tidelands development, and prompt reconsideration of the probable effects upon drilling operations if efforts to reduce the depletion allowance are successful. Oil supply is a "must" in the United States now, and nothing should be permitted to interfere with the progressive supply program of the oil industry.

*Petroleum Consultant, Dallas, Texas.

Heavy fuel demand. Demand for fuel oil has been unusually heavy due to the protracted sub-zero temperatures over most of the nation. Fuel oil consumption rose to a new high level of 3,707,000 bbl daily in January, marking an increase over a year ago of about 19 per cent. Fuel oil stocks at the close of January were 17 per cent below last year, and represented only 32 days supply, against 38 days supply last year. Refinery runs were sharply increased in January, to a daily average of 6,440,000 bbl. This is 13 per cent above last year. Fuel oil stocks were reduced about 14,000,000 bbl in January, despite substantial increases in refinery production and imports. Motor fuel demand rose to a January peak of 2,719,000 bbl, 23 per cent above last year.

Oil search brisk. The search for new oil fields in the United States continued at a brisk rate in January, when 726 wildcat wells were drilled. This marked an increase over a year ago of 36 per cent. The success of these efforts was reflected by the completion of 125 oil wells and 26 gas wells. Oil well completions were 39 per cent greater than last year, while gas well completions rose 30 per cent. Illinois and Louisiana were the only exceptions to the upward trend in wildcat drilling operations.

Comparative Statistics, January, 1951

*All figures are computed on a Bureau of Mines' Basis**

	Jan. 1951Ⓟ	Dec. 1950Ⓡ	Jan. 1950	This Year to dateⓅ	Last Year to date	Per cent change
Total supply,* all oils	230,406	227,257	193,735	230,406	193,735	+18
Daily average	7,432	7,331	6,250	7,432	6,250	
Total demand,‡, all oils	240,678	232,676	204,397	240,678	204,397	+18
Daily average	7,763	7,505	6,593	7,763	6,593	
Change in stocks	—10,272	—5,419	—10,662	—10,272	—10,662	
Crude supply*	198,900	194,750	167,692	198,900	167,692	+18
Daily average	6,416	6,282	5,409	6,416	5,409	
Crude demand‡	201,900	193,090	174,438	201,900	174,438	+16
Daily average	6,513	6,229	5,627	6,513	5,627	
Crude stocks	245,500	248,500	246,610	245,500	246,610	— 1
Days supply	37	39	44	37	44	
Natural gasoline production	17,500	16,500	15,063	17,500	15,063	+17
Daily average	564	532	485	564	485	
Motor fuel production	95,100	90,100	82,043	95,100	82,043	+16
Daily average	3,068	2,906	2,647	3,068	2,647	
Gasoline yield, per cent	41.5	41.3	42.8	41.5	42.8	— 1.3
Motor fuel demand‡	84,290	82,180	68,473	84,290	68,473	+23
Daily average	2,719	2,651	2,209	2,719	2,209	
Motor fuel stocks	127,310	116,500	123,987	127,310	123,987	+ 2
Days supply	47	44	56	47	56	
Fuel oil production	86,640	81,000	69,980	86,640	69,980	+24
Daily average	2,795	2,613	2,257	2,795	2,257	
Fuel oil demand‡	114,940	109,340	96,794	114,940	96,794	+19
Daily average	3,707	3,527	3,122	3,707	3,122	
Fuel oil stocks	100,200	119,500	119,740	100,200	119,740	—17
Days supply	32	34	38	32	38	
Refinery still runs	199,660	189,343	169,987	199,660	169,987	+18
Daily average	6,440	6,108	5,483	6,440	5,483	
Stocks, all oil	582,978	594,250	592,457	582,978	592,457	— 1
Days supply	75	79	90	75	90	

Current Crude Oil Prices

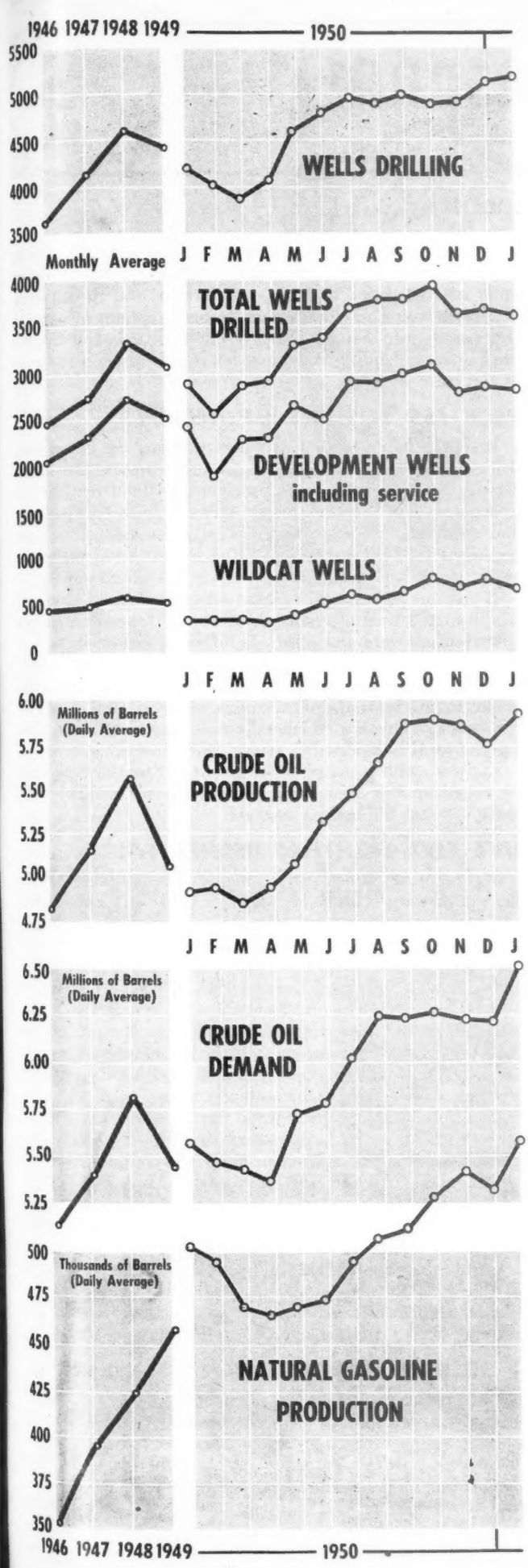
U. S. average	$2.58	Louisiana	$2.62	**Basic crude prices:**	
Texas	2.61	Arkansas	2.43	Oklahoma-Kansas (36 gr.)	$2.57
California	2.42	New Mexico	2.40	Texas Gulf Coast (36 gr.)	2.80
Oklahoma	2.62	Mississippi	2.23	East Texas	2.65
Kansas	2.62	Illinois	2.76	West Texas (36 gr.)	2.44
		Other states	2.60	California Signal Hill (26 gr.)	2.31
				Pennsylvania, Bradford	4.25

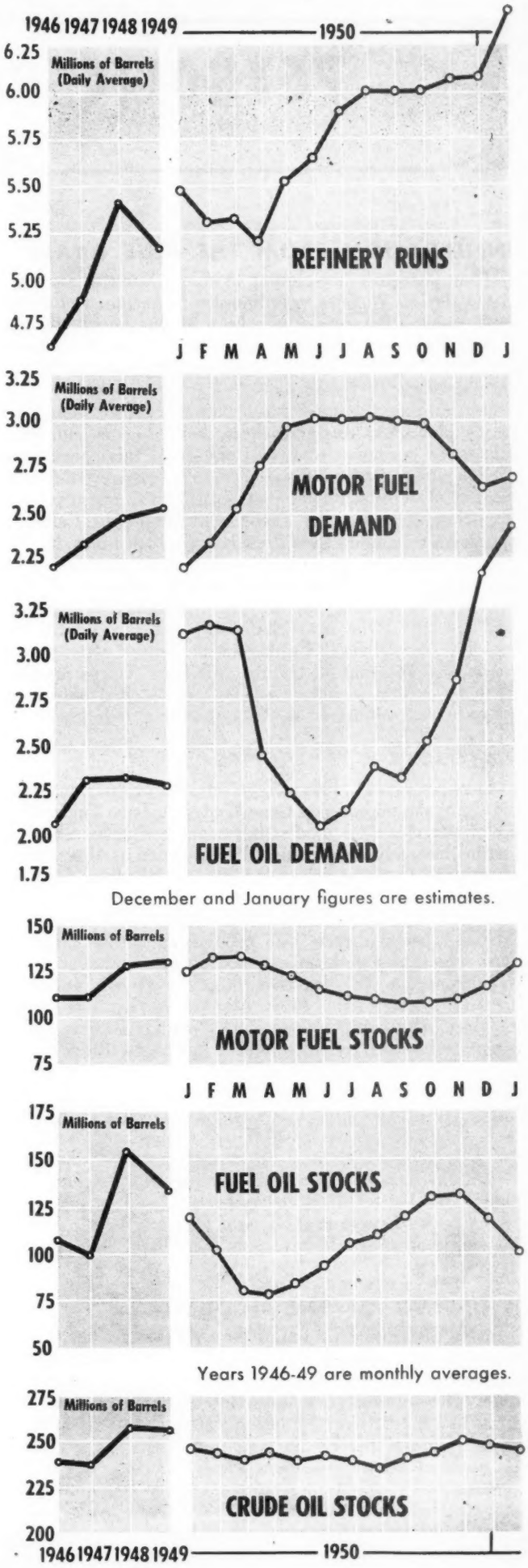
Drilling and Production Statistics

	Jan. 1951Ⓟ	Dec. 1950Ⓡ	Jan. 1950	This Year to dateⓅ	Last Year to date	Per cent change
Wells drilling	5,210	5,150	4,585	5,210	4,585	+13
Total wells drilled	3,624	3,701	3,255	3,624	3,255	+11
Development wells	2,849	2,895	2,630	2,849	2,630	+ 8
Oil	1,917	1,982	1,818	1,917	1,818	+ 5
Gas	208	227	210	208	210	— 1
Dry	724	686	602	724	602	+20
Per cent dry	25.4	23.7	22.9	25.4	22.9	+ 2.5
Service wells	49	51	92	49	92	—47
Wildcat wells	726	755	533	726	533	+36
Oil	125	115	90	125	90	+39
Gas	26	17	20	26	20	+30
Dry	575	623	423	575	423	+36
Per cent dry	79.2	82.5	79.4	79.2	79.4	— 0.2
By State						
Wells drilled (excl service)	3,575	3,650	3,163	3,575	3,163	+13
Arkansas	48	33	34	48	34	+41
California	138	166	152	138	152	— 9
Illinois	199	220	210	199	210	— 5
Kansas	356	362	253	356	253	+41
Louisiana	190	219	240	190	240	—21
Mississippi	17	13	28	17	28	—39
New Mexico	51	41	62	51	62	—18
Oklahoma	496	487	370	496	370	+34
Texas	1,469	1,519	1,256	1,469	1,256	+17
Other states	611	590	558	611	558	+ 9
Wildcats drilled	726	755	533	726	533	+36
Arkansas	12	7	10	12	10	+20
California	33	42	26	33	26	+27
Illinois	38	45	47	38	47	—19
Kansas	81	96	40	81	40	+102
Louisiana	26	31	29	26	29	—10
Mississippi	7	6	7	7	7	0
New Mexico	12	11	7	12	7	+71
Oklahoma	103	58	70	103	70	+47
Texas	317	359	211	317	211	+50
Other states	97	100	86	97	86	+13
Daily crude production	5,939	5,766	4,922	5,939	4,922	+20
Arkansas	81	85	86	81	86	— 6
California	968	971	867	968	867	+11
Illinois	160	170	165	160	165	— 3
Kansas	312	303	270	312	270	+15
Louisiana	625	610	560	625	560	+12
Mississippi	104	103	98	104	98	+ 6
New Mexico	140	133	131	140	131	+ 7
Oklahoma	500	500	394	500	394	+27
Texas	2,593	2,454	1,962	2,593	1,962	+32
Wyoming	192	187	150	192	150	+28
Other states	264	250	239	264	239	+10

* Unless otherwise stated all figures represent thousands of barrels. ‡ Total demand, including exports. • Includes domestic production and imports. Ⓟ Preliminary. Ⓡ Revised.

Preliminary estimates based upon data supplied by American Petroleum Institute, U. S. Bureau of Mines, State Agencies, and other official sources.





December and January figures are estimates.

Years 1946-49 are monthly averages.

PETROLIC PERSONALITIES

DICK SNEDDON

INFILTRATION FROM THE BLUE GRASS

That peaceful, law-abiding hamlet, Nuestra Senora la Reina de Los Angeles, was literally rocked to its subterranean deeps a few moons ago by a mighty social upheaval that really didn't engage so many people, but was nonetheless responsible for such a release of Btu's as hasn't been seen since the Bikini episode.

It all began quite innocently when a group of Tube Turns people shook the blue grass from their brogans and, led by that noted consumer of Coca-Cola, John Seiler, converged relentlessly on the western metropolis. Arrived there, the Kentucky contingent was met and greeted warmly by an imposing delegation of Bethlehem Supply of California people that included Vice President Wendell Jones, the badminton whiz, and other pretty substantial members of this august institution. There then ensued a succession of elucidations, discussions, and debates—all aimed at defining and developing the new relationship between Tube Turns, Inc., and Bethlehem of California, the latter having just become an important distributor of Tube Turns products. That, of course, is old news now but is cited here as an essential preliminary of the declamation that follows.

PRELIMINARY EXERCISES

A couple of days prior to the opening of this consequential clambake we had met Gene Wedereit, Tube Turns director of advertising, a modest but capable chap to whom we just instinctively took a shine. He informed us of a pending whangaroo that was scheduled for the following Saturday night at a delightful hostelry, known as the House of Murphy. So, in preparation for what we felt sure would transpire, we withdrew into our cocoon for a couple of days, which was well, indeed, we can assure you.

To continue the narrative, however, on the appointed Saturday night we hied to the hostelry aforesaid and found the place practically in possession of the Tube Turns—Bethlehem forces. All other elements had been diffused and scattered to the point of inutility (a tidy word, don't you think, for a lad who is paid by the syllable). Anyway, we swaggered into the joint like a regular habituee of the night spots (actually we do most of our dining out at Whelp's Dairy Lunch — beef stew 19 cents) and before we had crossed the threshold were shot twice by Fred Stiefler, Bethlehem's public relations representative, and in the meantime a flock of street arabs fought for our autograph, little knowing that we would have paid them handsomely to take it.

WHIPPING OF THE ACOUSTICS

Inside the edifice we found the wall plastered with people, all in that state of reticence and psuedo-decorum that normally is the prelude to an outbreak of something or other. The serving girls were dashing about helping the guests to a miscellany of tittering waters and presently there was a quite notable rise in temperature. Impromptu quartets blossomed here and there and by the time dinner had commenced everybody was so thoroughly acquainted that introductions were ridiculous.

But it was what happened after dinner that stimulated this gush of words. No sooner was it over than—as naturally as oil migrating to a well bore—the vocalists one by one drifted over in the direction of Wendell Jones and presently an Eisteddfod of major proportions was in full sway. Wherever you find a Welshman, sooner or later an eisteddfod comes into being, and this one was a honey. Such a harmonious blending of tenors, leads, baritones, and bassos is certainly a rarity.

RECKLESS TOSSERS OF DECIBELS

It should be noted that prominent among the out-of-town delegates to this interesting convention was C. R. "Red" Zimmerman, executive vice president of Bethlehem Supply Company, Tulsa, Oklahoma, a songster with tonal quality and enunciatory finesse that is really top hole. On divers occasions we have joined with Red in concerted vocalizing and if we do say so ourself, the result was mighty sweet.

It can be well imagined thus what a glorious diapason rose into the welkin when added to the Jones-Zimmerman contribution were the offerings of such virtuosos as Carl McLaughlin, manager of Tube Turns engineering service division, whose sonorous basso gave pleasing substance to the total effect; Ralph Clemons, Gene Correll, and Carl Hitchcock, a trio of Bethlehemites who put their heads close together and compounded some blends that were sure easy on the ear; and a dozen other proficient warblers who by no means spared their tonsils as they tossed decibels recklessly into the expanding cantata.

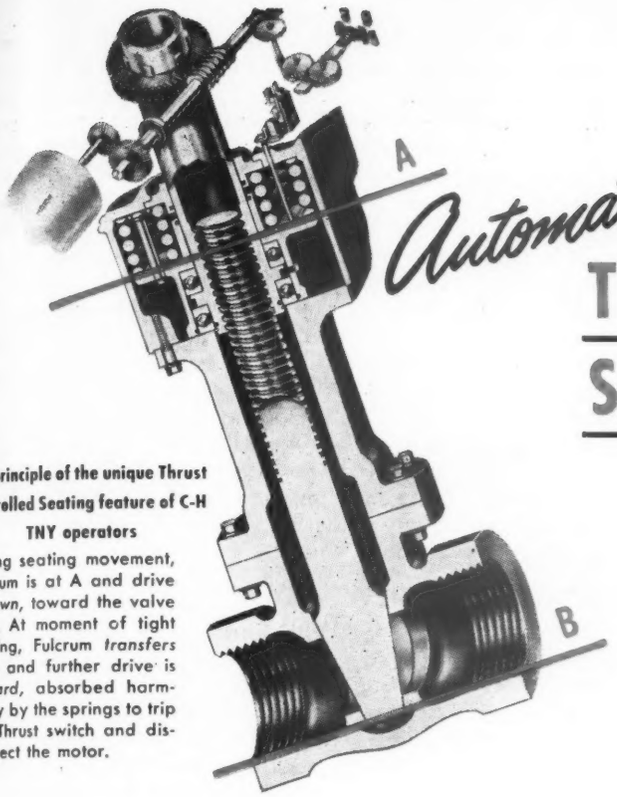
FIVE FEET, EIGHTEEN INCHES TALL

Representing Tube Turns, in addition to those already mentioned were John B. Hendy, vice president, plant manager, and highly respected citizen of Louisville, Kentucky; Lewis M. Bounds, Jr., the personable west coast district manager; John Churnbley, sales manager of the forgings division, who informed us much to our surprise that no woman had ever won the Kentucky Derby—it has always been won by a horse; Earl Muir, salesman from San Francisco, the bustling bailiwick with the beautiful bridgework; and Norton P. Bosemer, well known and highly regarded manager of the Los Angeles office.

The Bethlehem contingent, a fairly large one was enhanced no end by the presence of Jack Hollingsworth, general sales manager, a likeable chap of sizable dimensions and altogether friendly inclinations. Jack is unquestionably a tall man but alongside Jim Bogle, the Taft representative who was also present, he appears to be of just medium height. Jim seems to be about the height of a service derrick and when approached on the subject he readily admits to 5 feet 18 inches. Meanwhile, Gene Wedereit and Fred Stiefler fired flash guns from all angles, investing the proceedings with a decidedly Hollywoodish aura or something.

A SOUTHERN GENTLEMAN

And now returning to the main actors in this industrial drama, we might point out that John Gray Seiler, the young looking executive vice president of Tube Turns, Inc., is a native of Louisville, attended high school there, and is a Kentuckian in the traditional sense. He loves a thoroughbred race horse, especially when it passes the winning post ahead of the flock with a pair of his simoleons balanced on its nose; has an unerring eye for an equine crock; and can



The principle of the unique Thrust Controlled Seating feature of C-H TNY operators

During seating movement, Fulcrum is at A and drive is *down*, toward the valve seat. At moment of tight seating, Fulcrum *transfers* to B and further drive is *upward*, absorbed harmlessly by the springs to trip the Thrust switch and disconnect the motor.

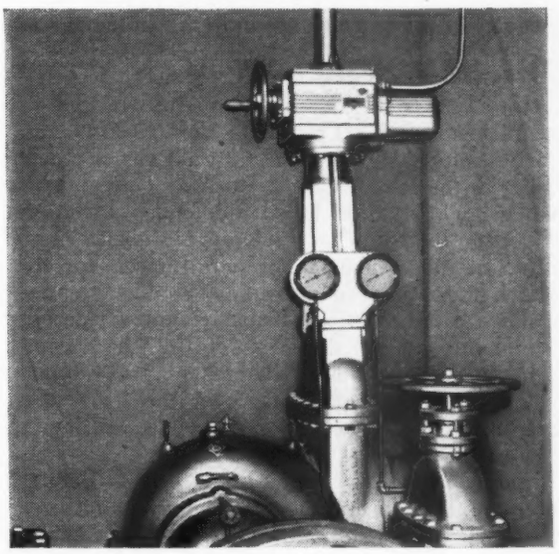
Automatic Valve Operation?

Thrust Control makes it Safe and Accurate, too!

IN THE petroleum industry, automatic, instant and swift motorized valve operation is an economic "must." Distance, difficulty, frequency of operation and danger are factors that urge such a step.

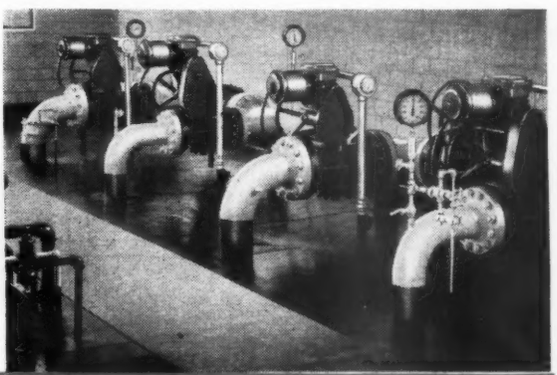
But the problem is also one of *accurate* and *safe* seating . . . as assured by the Thrust Control principle employed exclusively in Cutler-Hammer Valve Operators. The motor *positively* drives the valve disc home. During the driving period, the fulcrum is established at the yoke nut by heavy steel springs which exactly balance *tight seat pressure*. Therefore, at the very instant of desired tight seating, the driving fulcrum transfers to the seat of the valve, hence any further drive is into the yoke nut, against the heavy springs which harmlessly absorb motor drift. The movement of the yoke nut against the springs trips the *THRUST* switch to disconnect the motor. The amazing part is that the same degree of tight seating is maintained no matter how much valve parts may expand or contract. No other valve operator has or can have this direct *THRUST* controlled feature. No other valve operator can be as safe and sure and accurate. CUTLER-HAMMER, Inc., 1459 St. Paul Avenue, Milwaukee 1, Wisconsin.

CUTLER-HAMMER
VALVE CONTROL
C-H

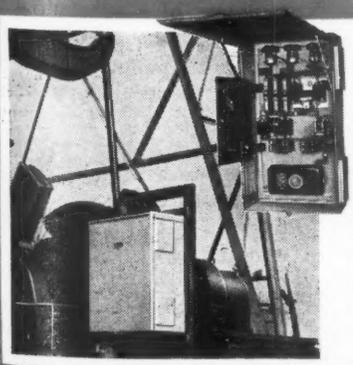


Exclusive Cutler-Hammer Thrust Control Valve Operators from few pounds thrust up to 80 TONS can be applied to any gate valves in the petroleum industry.

For valves which do not seat, such as the plug type valves, C-H B2 automatic declutching valve operators act swiftly and stop instantly.

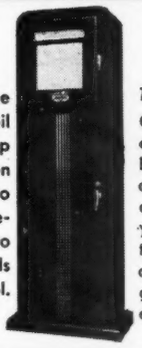


OTHER CUTLER-HAMMER PRODUCTS FOR THE OIL AND GAS INDUSTRY



Long-lasting control that "schedules" oil well pumping

This Cutler-Hammer Motor Control Device built to the rigid requirements of tough oil country service automatically starts pump going and shuts it down in synchronization with oil well capacity or in conformity to operating schedule. You can set up any sequence of day and night operation, set it to skip certain days. Bulletin 9589D-21 tells all about this amazing pumping control. Send for free copy.



Know what you are buying, selling, giving away

These "gas counting" instruments tell you accurately

Cutler-Hammer Calorimeters . . . standard wherever gas is bought or sold—actually count the B. t. u.'s per cubic foot of the gas you are sending or receiving. Accurate within 1%. They also write a continuous 24-hour a day permanent record so you know at all times exactly what is going through your piping system . . . for accurate accounting and billing, and for accurate control of gas heating value. Free booklet "Where Experience Counts" tells all about C-H B. t. u. Control.

wax lyrical over the virtues of bourbon, although he is strictly a "coke" man himself. He has been with Tube Turns, Inc., since 1930 and was elevated to his present high post in 1948. John combines genuine administrative talent with a rare gift for making and keeping friends. He is no swivel-chair leader, but a travel-minded chap who believes in getting around the country and learning at first hand what distributors and customers want in the line of products and services.

His chief recreation is golf and report has it that for one whose business schedule allows little opportunity for practice, he is a pretty sharp performer. His stance and swing would do credit to a Scottish bagpiper, and he putts with the infallibility and consistency of a high grade outboard motor. From all accounts he is also an excellent judge of the gentler sex, which gives him the complete attributes of the proverbial southern gentleman.

THE BALTIMORE ORIOLE

C. R. "Red" Zimmerman, executive vice president of Bethlehem Supply Company, Tulsa, Oklahoma, was born in Baltimore, Maryland, a city that has also acquired some fame as the seat of Johns Hopkins University. During his early boyhood, Red lolled indolently on the banks of the Patapsco but you'd never know it the way he gets around now. In due course, to prepare himself for the rigors to which he is at present being subjected he attended St. John's College at Annapolis, Maryland, and absorbed a grist of useful information. Then about 1927 he accepted his first job—in the pipe mills of Bethlehem Steel Company at Sparrows Point—and gradually over the succeeding years he rose through increasingly responsible positions to his present eminence.

Before leaving Sparrows Point to go to Bethlehem, Pennsylvania, he had become special representative, and after a thorough indoctrination in the pipe sales department there, he was transferred to Tulsa, Oklahoma, in July, 1948. Businesswise, Red is a competent and capable administrator, but socially he is an easy to know sort of chap who likes to take part in impromptu quartets and really has a very fine voice. In school he was for a time active in wrestling, but is reported to have given up his interest in this exhausting pastime when he had the misfortune to suffer an attack of laryngitis and could hardly groan above a whisper.

LIKES SAILING

Wendell Jones, vice president and general manager of Bethlehem Supply Company of California, was born in Maine, but showing unusually good taste for a child of his years, moved to California at the early age of 18 months. He graduated from the University of California in engineering in 1916, then spent some time in the army. He claims to have fought in the battles of San Francisco Presidio and Camp Fremont in the California campaign and then fought hard through sundry eastern training camps. When the fracas was all over in 1919 he emerged with no medals, no wounds, no overseas stripes, but an unshakable desire to get to work. Beginning as a roughneck in the Ventura, California, area, he spent the next eight years in drilling and production work, eventually reaching the status of chief production engineer. In 1928 he entered the supply business in the employ of the Petroleum Equipment Company and when this firm was taken over by Bethlehem Steel Company in 1945 and Bethlehem Supply Company of California was formed, he was retained as one of the more valuable assets.

Wendell is an exuberant chap, simply bubbling over with energy and radiant with good health. He likes people and people consequently like him. For many years he has been a member of the Wildcat Committee of Western Oil and Gas Association and has played leading roles in the oil men's Christmas Play, staged by this group annually in the Biltmore Bowl. He loves partying and being partied and whether he is host or guest he is always an elevating influence in any gathering. He has a good tenor voice and loves a community sing.

ECHOES OF NEW YORK

From New York via Paul Whiteley, the popular Angelenic disciple of Pegasus, comes a very nice pencil sent by Joe Taylor, purchasing agent of Socony Vacuum Oil Company, an extremely interesting and affable chap whom we had the pleasure of meeting during the late lamented API convention. Joe is a consequential citizen of Manhattan who appears to be known all over the United States and to be highly regarded wherever he is known. Without leaving his native country he has had more adventure than the Swiss family Robinson, and being blessed with an excellent memory and a good sense of humor he can recite his adventures in a most interesting manner.

Incidentally, his right hand man, Bill Beck, was a recent visitor in California and the Nineteeners hurriedly arranged a lunch party at the Jonathan Club in his honor. Joe and Bill are both members of the Nineteeners, a somewhat exclusive institution whose members meet at a different golf club in the Los Angeles area each month, and having soundly trounced the lush earth, repair to the locker rooms and engage in less strenuous calisthenics.

THE FINAL WORD

By way of last minute roundup, Basil Kantzer, the well known Union Oil Company sculptor has bent his artistic talent in a new direction and is now turning out some excellent pieces in tooled copper. Basil is now the chief engineer of a substantial industry public relations program embracing the Southern California area, and is busier than a dirndl skirt in a windstorm. Ted Sutter, executive vice president of Baker Oil Tools, Inc., is, as we write back in Washington, D. C., attending to his multifarious duties. Ted is one of the most occupied people in the West. President of PESA, he has more extra-curricular activities than an amateur magician.

H&L Teeth

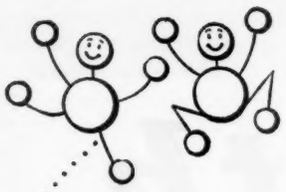
Teeth that really Dig!

STANDARD EQUIPMENT ON PIPELINE JOBS.

H&L TOOTH COMPANY

PIONEER MANUFACTURERS OF TWO-PART TEETH

DEALERS LOCATED IN STRATEGIC POINTS TO INSURE PROMPT SERVICE



1,000°F.

Where molecules DANCE or DIE...

TAGLIABUE RECORDERS Chart Changing Temperatures

From the mad molecular dance at a thousand degrees to the killing cold of three hundred below, TAGliabue Recorders faithfully chart changing temperatures for future reference. Whether your requirements are for a sensitive instrument spanning but a few degrees . . . for a model built for one temperature extreme or the other . . . or for a conventional instrument that's adaptable to myriad industrial applications—you will find a TAG Temperature Recorder that meets your every need.

And in all TAG Recorders you can count on the same simple, sound design . . . the same sturdy construction . . . that have long kept TAGliabue leaders in temperature instrumentation.

Feel free to call on your TAG Representative for assistance in applying these modern instruments to your processes.

0°F.

−300°F.

TAGLIABUE INSTRUMENTS DIVISION

Weston Electrical Instrument Corporation

614 Frelinghuysen Avenue, Newark 5, New Jersey

TAGliabue Dial Thermometers Provide Remote Indications

Temperatures are accurately shown at a distance from the sensing element with the Dial Indicating Thermometers produced by TAGliabue Instruments Div., Dept. 67, Weston Electrical Instrument Corp., Newark 5, N. J. These sturdy devices are furnished with mercury, gas filled or vapor tension actuations in 5, 6 and 8" dial sizes.

The plain black pointer and figures make TAG Dial Indicating Thermometers easy to read. The instruments are made in two types, for flush or wall mounting, with cases of iron, brass or phenolic plastic. Models are available to indicate as low as −325°F. or as high as 1000°F.

CELECTRAY Recorders Find Widespread Application

Variables expressed as potentials or resistances are accurately charted with the CELECTRAY Recorders manufactured by TAGliabue Instruments Div., Dept. 67, Weston Electrical Instrument Corp., Newark 5, N. J. While these instruments are widely used with thermocouples as recording pyrometers, other applications are also feasible.

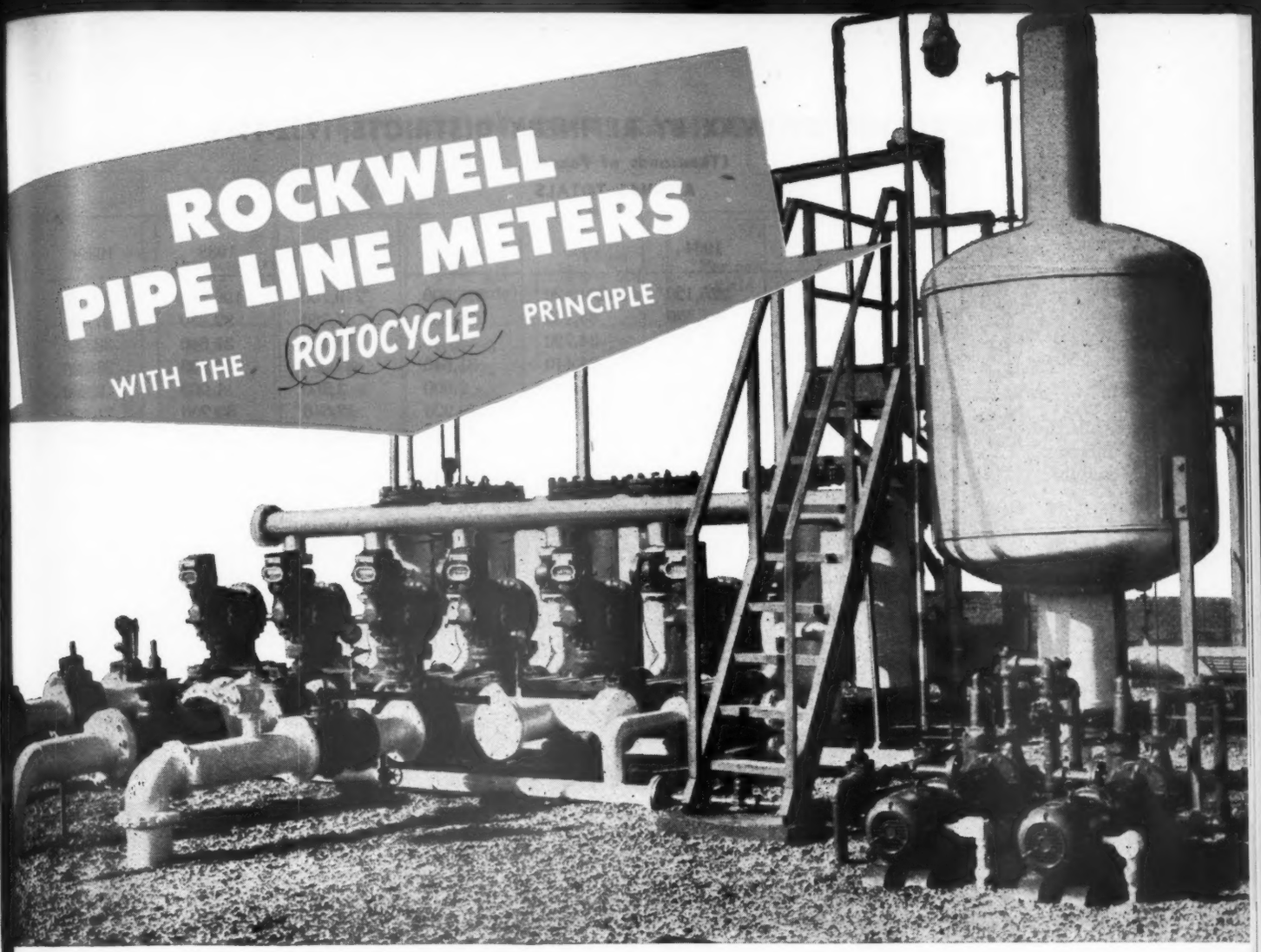
They are calibrated with Weston "Photronic" photoelectric cells for use as light recorders, or teamed with related Weston instruments to record slip, stretch, speed ratio, pH, voltage, current or power. CELECTRAY instruments, available in Wheatstone Bridge or Potentiometer types, operate on the inertialess light-beam principle and record up to twelve points on one chart.

"TAG" Glass Thermometers Provide Lasting Precision

Accurate general purpose and laboratory thermometers are supplied by TAGliabue Instruments Div., Dept. 67, Weston Electrical Instrument Corp., Newark 5, N. J. Available armored or unarmored, these individually etched stem thermometers indicate temperatures as low as —150° or as high as 950°F. in the standard grade, and values as low as —30°F. or as high as 750°F.

in the extreme precision grade. Limited range thermometers graduated to 1/100°C., for calorimeter use, are also standard.

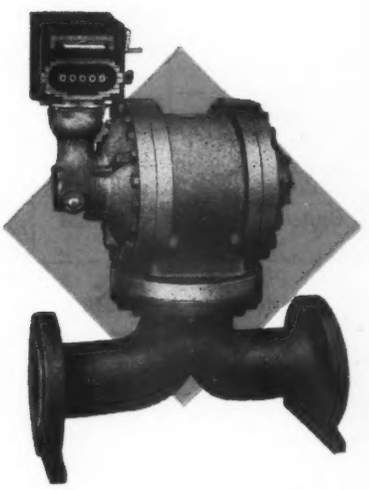
In addition to individual instruments, matched sets of A.S.T.M. Testing Thermometers, with overlapping ranges spanning temperatures from —36°F. to 760°F., or —38 to 405°C., are available in convenient simulated leather cases.



PAY OFF *where you take off!*

When you guard your take-offs with Rockwell Rotocycle meters you protect your pay-off points in two ways. First you gain the mechanical advantages of a proved meter design that has rolled up impressive durability records on the nation's leading pipe lines. Second you are assured of precision accuracy that accounts for every drop of throughput and every penny of return.

Rockwell Rotocycle meters are made in five sizes for either high or low pressure service and may be optionally fitted with temperature compensators, straight reading or printing registers. Write for bulletins and case histories of actual operator's experience.



Model 6 PL Rockwell Rotocycle with printing register. Capacity 1150 barrels per hour.

Rockwell MANUFACTURING COMPANY
PITTSBURGH 8, PA.

Atlanta Boston Chicago Columbus Houston Kansas City
Los Angeles New York Pittsburgh San Francisco Seattle Tulsa

PRODUCTION OF WAX BY REFINERY DISTRICTS, 1932-1947

(Thousands of Pounds)

ANNUAL TOTALS

District	1932	1933	1934	1935	1936	1937	1938	1939
East Coast	209,440	233,520	225,120	204,120	215,600	249,760	196,560	189,840
Appalachian	85,120	69,160	81,480	83,160	82,880	87,360	82,880	97,160
Ind., Ill., Ky., etc.	42,560	25,760	37,800	34,720	38,360	43,120	31,640	38,080
Okla., Kans., Mo.	28,840	29,120	34,720	34,440	31,640	33,600	30,800	31,920
Texas Inland	3,080	3,080	2,800	3,360	2,800	3,360	1,960	2,800
Texas Gulf	29,120	44,520	45,360	47,600	59,920	52,640	60,200	71,120
Louisiana Gulf	50,960	57,400	25,760	20,440	22,680	28,000	19,600	22,400
Ark., La. Inland	0	0	0	0	0	1,680	280	0
Rocky Mountain	9,800	7,000	15,680	22,400	19,040	22,120	11,480	11,200
California	0	0	0	0	0	0	0	0
United States	458,920	469,560	468,720	450,240	472,920	521,640	435,400	464,520

District	1940	1941	1942	1943	1944	1945	1946	1947
East Coast	196,000	233,520	213,640	246,680	286,720	309,400	310,240	388,360
Appalachian	100,240	112,000	119,280	101,080	102,480	102,480	99,960	111,160
Ind., Ill., Ky., etc.	54,600	49,280	57,960	64,680	62,160	60,200	53,760	63,560
Okla., Kans., Mo.	39,480	44,800	57,960	78,680	84,840	90,160	106,960	133,000
Texas Inland	1,400	1,400	3,360	3,080	2,520	2,240	2,520	3,080
Texas Gulf	76,440	122,640	140,560	143,080	129,080	122,080	130,200	147,840
Louisiana Gulf	28,000	89,320	85,400	93,520	99,680	82,320	89,600	115,640
Ark., La. Inland	0	0	0	0	0	0	0	0
Rocky Mountain	17,080	17,080	22,400	21,000	24,640	25,200	21,840	26,600
California	0	0	0	3,360	15,120	23,800	25,760	25,480
United States	513,240	670,040	700,560	755,160	807,240	817,880	840,840	1,014,720

DAILY AVERAGES

District	1932	1933	1934	1935	1936	1937	1938	1939
East Coast	572	640	617	559	589	684	538	520
Appalachian	233	189	223	228	226	239	227	266
Ind., Ill., Ky., etc.	116	71	103	95	105	118	87	104
Okla., Kans., Mo.	79	80	95	94	86	92	84	88
Texas Inland	8	8	8	9	8	9	5	8
Texas Gulf	80	122	124	131	164	144	165	195
Louisiana Gulf	139	157	71	56	62	77	54	61
Ark., La. Inland	0	0	0	0	0	5	1	0
Rocky Mountain	27	19	43	61	52	61	31	31
California	0	0	0	0	0	0	0	0
United States	1,254	1,286	1,284	1,233	1,292	1,429	1,193	1,273

District	1940	1941	1942	1943	1944	1945	1946	1947
East Coast	535	640	585	676	783	848	850	1,064
Appalachian	274	307	327	277	280	281	274	304
Ind., Ill., Ky., etc.	149	135	159	177	170	165	147	174
Okla., Kans., Mo.	108	123	159	216	232	247	293	365
Texas Inland	4	4	9	8	7	6	7	8
Texas Gulf	209	336	385	392	353	334	357	405
Louisiana Gulf	76	245	234	256	272	226	245	317
Ark., La. Inland	0	0	0	0	0	0	0	0
Rocky Mountain	47	47	61	58	67	69	60	73
California	0	0	0	9	41	65	71	70
United States	1,402	1,836	1,919	2,069	2,205	2,241	2,304	2,780

Source: U. S. Bureau of Mines

REFINERS' MARGIN, CALIFORNIA AREA

Year	Gasoline				Kerosine			
	Per cent yield	Gal per bbl of charge	Price ¢ per gal (reg grade)	Value $ per bbl of charge	Per cent yield	Gal per bbl of charge	Price ¢ per gal (38°—40°; 40°—43° Gr W.W.)	Value $ per bbl of charge
1928	25.93	10.68	10.80	1.153	3.97	1.67	5.76	0.096
1932	34.02	14.29	9.92	1.418	3.63	1.52	4.37	0.066
1936	34.03	14.29	7.65	1.093	2.06	0.87	4.33	0.038
1937	32.98	13.85	9.05	1.253	2.47	1.04	5.00	0.052
1938	32.01	13.44	8.88	1.193	2.11	0.89	6.13	0.055
1939	32.83	13.79	8.76	1.208	2.34	0.98	5.71	0.056
1940	32.44	13.62	7.47	1.017	1.66	0.70	5.25	0.037
1941	33.75	14.18	6.76	0.959	1.01	0.42	5.25	0.022
1942	30.93	12.99	5.60	0.727	1.03	0.43	4.51	0.019
1943	29.54	12.41	5.81	0.721	1.29	0.54	4.88	0.026
1944	32.33	13.58	6.50	0.883	0.93	0.39	5.79	0.023
1945	32.82	13.79	7.00	0.965	0.89	0.37	5.00	0.019
1946	32.80	13.78	7.15	0.985	1.36	0.57	7.05	0.040
1947 ℗	33.59	14.11	10.19	1.438	1.54	0.65	8.93	0.058

Year	Gas oil and distillate fuel oil				Residual fuel oil			
	Per cent yield	Gal per bbl of charge	Price ¢ per gal (Avg Diesel fuel and stove dist)	Value $ per bbl of charge	Per cent yield	Gal per bbl of charge	Price ¢ per gal (Avg lt and hvy fuel oil)	Value $ per bbl of charge
1928	14.47	6.08	2.74	0.167	49.84	20.93	2.12	0.444
1932	10.02	4.21	1.74	0.073	42.98	18.05	1.32	0.238
1936	13.65	5.73	1.39	0.080	43.12	18.11	1.95	0.353
1937	14.17	5.95	2.79	0.166	42.92	18.03	1.90	0.343
1938	14.52	6.10	4.01	0.245	43.10	18.10	1.90	0.344
1939	15.07	6.33	3.47	0.220	40.66	17.08	1.81	0.309
1940	14.23	5.98	3.41	0.204	41.90	17.60	1.45	0.255
1941	13.04	5.48	3.39	0.186	41.47	17.42	1.67	0.291
1942	10.62	4.46	3.84	0.171	45.40	19.07	2.05	0.391
1943	10.93	4.59	4.15	0.190	48.01	20.16	2.60	0.524
1944	10.01	4.20	4.61	0.194	46.30	19.45	2.76	0.537
1945	9.38	3.94	4.64	0.183	47.04	19.76	2.76	0.545
1946	14.45	6.07	5.08	0.308	41.86	17.58	3.00	0.527
1947 ℗	15.39	6.46	7.31	0.472	38.12	16.01	4.12	0 660

Year	Other products*				Total value realized	Price 26° gr Sig Hill crude oil at well	Refiners' margin	Ratio
	Per cent yield	Gal per bbl of charge	Price ¢ per gal (reg grade)	Value $ per bbl of charge	$ per bbl of charge	$ per bbl	$ per bbl of crude oil run	Price per bbl of crude oil to price per gal gasoline
1928	2.71	1.14	6.09	0.070	1.93	0.96	0.97	8.9
1932	5.82	2.45	2.55	0.062	1.86	0.83	1.03	8.4
1936	7.02	2.95	2.58	0.076	1.64	1.00	0.64	13.1
1937	7.35	3.09	2.64	0.082	1.90	1.03	0.87	11.4
1938	7.55	3.17	2.49	0.079	1.92	1.03	0.89	11.6
1939	8.45	3.55	2.61	0.093	1.89	1.03	0.86	11.8
1940	8.87	3.72	2.31	0.086	1.60	0.96	0.64	12.9
1941	10.20	4.29	2.53	0.109	1.57	1.03	0.54	15.2
1942	10.73	4.51	2.20	0.099	1.41	1.11	0.30	19.8
1943	8.79	3.69	2.28	0.084	1.55	1.11	0.44	19.1
1944	8.56	3.60	2.61	0.094	1.73	1.11	0.62	17.1
1945	8.23	3.46	2.53	0.088	1.80	1.11	0.69	15.9
1946	8.51	3.57	3.55	0.127	1.99	1.29	0.70	18.0
1947 ℗	9.25	3.89	3.18	0.124	2.75	1.76	0.99	17.3

℗Preliminary.

*Includes lube oil, wax, coke, asphalt, road oil, still gas.

Source: Product prices from oil companies and published sources; balance of source data from U. S. Bureau of Mines; correlations by *The Petroleum Data Book* Research Department.

CONVERSION FACTORS

CRUDE PETROLEUM

The following conversion factors for converting crude petroleum from metric tons to barrels of 42 gallons each are based on the latest data available for each country:

COUNTRY	Conversion factor	COUNTRY	Conversion factor
Albania	6.672	India	7.240
Argentina	7.177	Iran	7.566
Austria	6.708	Iraq	7.481
Bahrein Island	7.328	Italy	7.652
Bolivia	7.716	Japan	7.030
British Borneo:		Mexico	6.810
Brunei	7.489	Netherlands East Indies	7.811
Sarawak	7.817	Peru	7.555
Canada	7.858	Poland	7.419
Colombia	6.966	Rumania	7.336
Czechoslovakia	6.787	Saudi Arabia	7.417
Ecuador	7.585	Trinidad	7.110
Egypt	7.002	U. S. S. R.	7.290
France	7.129	Sakhalin	6.750
Germany	6.993	United States	7.401
Hungary	7.433	Venezuela	6.703

REFINED PETROLEUM PRODUCTS

For refined products of petroleum, the following units have been employed for converting the original units of weight—usually metric—United States barrels:

TYPE	Gallons per pound	Pounds per gallon	Pounds per barrel	Barrels per short ton	Barrels per metric ton (2204.6 lb.)
Aviation gasoline	0.171	5.83	245	8.16	9.00
Motor gasoline	0.162	6.17	259	7.72	8.50
Kerosine	0.148	6.76	284	7.04	7.75
Gas oil, Diesel oil, distillate fuel oil	0.138	7.24	304	6.58	7.25
Residual fuel oil	0.127	7.88	331	6.04	6.66
Lubricating oils	0.133	7.51	315	6.35	7.00
Mineral oils, unspecified	0.133	7.51	315	6.35	7.00
Benzol	0.136	7.36	309	6.47	7.14
Mineral spirits, substitute turpentine	0.160	6.24	262	7.63	8.40
Paraffin wax			280	7.14	7.87
Petrolatum			280	7.14	7.87
Grease			350	5.71	6.30
Asphalt and road oil			364	5.50	6.06
Petroleum coke			400	5.00	5.50

Source: U. S. Bureau of Mines and American Petroleum Institute.

The photo above is another of a series of factual stories of how the Petroleum Industry is benefited by LOW COST Purchased Electric Power.

Automatic Control releases manpower and cuts payroll costs. *PEP works 24 hours a day or operates on any fractional time schedule — this means you pay only for power used. Now is the time — in '51 — to get the job done with LOW COST Purchased Electric Power!

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ORGANIZED IN THE INTEREST OF GREATER SERVICE TO THE PETROLEUM INDUSTRY

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LETTERS *to the* EDITORS

Praises Patent Paper

To The Petroleum Engineer:

I liked Paul F. Hawley's article (The Effect of Patents on Petroleum Production, Operation, and Development) in the January (1951) issue of *The Petroleum Engineer*. Very interesting.

A. M. Lockhart

Envoy Petroleum Company,
Long Beach, California.

Keeping Up With the Oil Producing Industry

To The Petroleum Engineer:

Enclosed please find a check for $2 for a three-year subscription to your *Exploration, Drilling and Production Magazine.*

I find reading your magazine is a very excellent way of keeping up with the portion of the industry in which I am interested. The company I am working for is engaged in water-flooding. Geographically we are separated from the big oil-producing sections of the country and without magazines such as yours it would be easy to lose touch with the oil producing industry.

David P. Bossler

Ottawa, Kansas.

ARCCO

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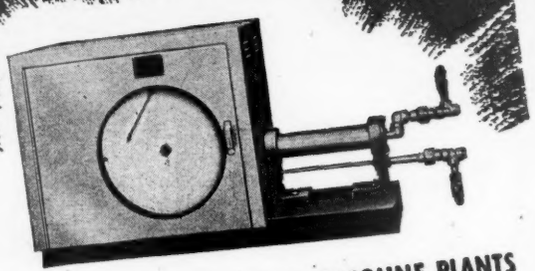
LIQUID GRAVITOMETER



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Service Company Lines

To The Petroleum Engineer:

Enjoyed your article re: Service Pipe Line Company on page D-3 (The Firing Line) of the December, 1950, *The Petroleum Engineer.*

Would it be possible to do Service Pipe Line Company full justice and reprint the map shown on page D-8 to include Service's line from Wyoming to the junction with its line from the south at Freeman, Missouri, near Kansas City?

Omission of SPL Company's line on this map gives the erroneous impression that Platte Pipe Line will be the first to bring crude oil from District IV to District II.

R. E. Watson

Chicago, Illinois.

Editor's Note: Publication of the map in in question was for the purpose of showing the route of Platte's proposed line and the area it will serve. There was no intention to minimize in any way Service's importance to Wyoming, and we are glad to publish this letter as a matter of information to our readers.

Nothing is Built by Tearing Down

"You cannot bring about prosperity by discouraging thrift.

You cannot strengthen the weak by weakening the strong.

You cannot help the wage earner by pulling down the wage payer.

You cannot further the brotherhood of man by encouraging class hatred.

You cannot help the poor by destroying the rich.

You cannot establish sound security on borrowed money.

You cannot keep out of trouble by spending more than you earn.

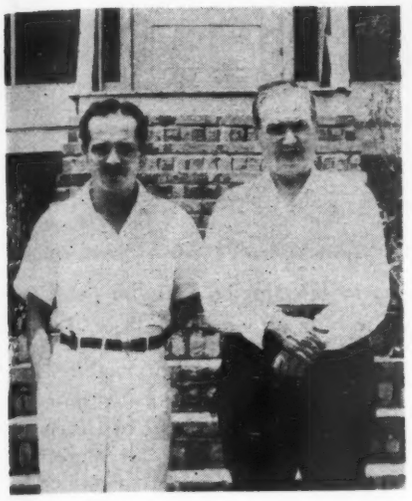
You cannot build character and courage by taking away man's initiative and independence.

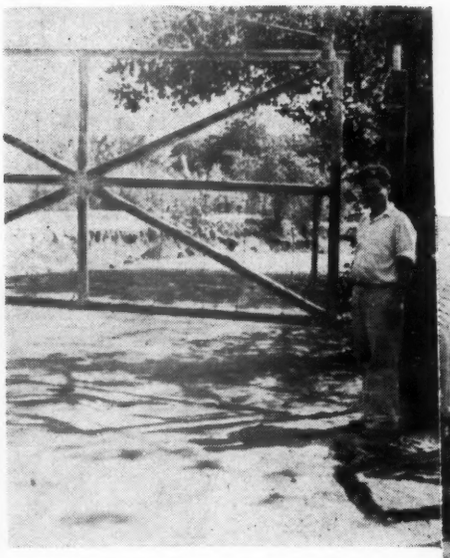
You cannot help men permanently by doing for them what they could and should do for themselves."

—*Abraham Lincoln*

THE Petroleum Engineer
MARCH, 1951

Antonio Moñino stands with the author, David Donoghue, in front of a staff dwelling.





La Puerta (the gate) on the De Mares Concession. This entrance is on the Barranca-El Centro road.

One of the houses at El Centro for staff members on the De Mares Concession.

Santander, Colombia

The De Mares Concession

DAVID DONOGHUE

LAS INFANTAS, in honor of the daughters of the king of Spain, was the name given by Gonzalo Jiménez de Quesada while on his historic march from the Caribbean coast to Bogotá in 1536, to the locality on the Río La Colorada where he observed seepages of oil and gas. Nearly 4 centuries later Colonel José Joaquín Bohórquez called the seepages to the attention of Roberto De Mares. On August 8, 1905, De Mares applied to the Colombian government for a concession on public lands around the seepages and on December 6, 1905, a contract was approved covering an area described as follows:

> From the mouth of the Río Sogamoso in the Río Magdalena, up this latter river to the mouth of the Río Carare, up this river to the foot of the Cordillera Oriental, and from here following along the foot of the said Cordillera to the Río Sogamoso, and down this river to the place first mentioned.

By a resolution of the Ministro de Obras Públicas dated March 14, 1921, the eastern boundary "following along the foot of the said Cordillera" was given a somewhat more definite description:

> From the mouth of the Rio Chucurí in the Río Sogamoso, a direct line to the junction of the Quebrada Las Flores with that of the Los Indios, thence in a direct line to where the Rio Opón breaks the Colina de Portones, thence in a direct line to the junction of the Quebrada de Armas with the Río Guayabito, and thence to the mouth of the Río Horta in the Río Carare.

Within these boundaries there are approximately 512,000 hectares. Also within these boundaries there are several tracts that are not a part of the De Mares Concession, or claims to that effect have been made, such as the Carare or López 95,960 hectares tract, the Lisama or La Putana Concession containing 7,858 hectares, and the Guayabito 10,000 hectares tract.

The 14 articles of the contract of December 6, 1905, included the obligation that the concesionario "organize a syndicate or company with sufficient capital to exploit the wells or seepages on a large scale" and to employ the capital in extracting crude petroleum, in refining, and in marketing at a price that would compete with imports from

EXCLUSIVE

Oil and gas seepage near wells No. 1 and No. 2 in Infantas area.

San Antonio seepages in Infantas-La Cira oil field. Fire was started by colonos to burn off weeds on their "farms."

Europe and the United States. The duration of the contract was to be 30 years from the beginning of the work of exploitation, and this beginning was to be within 18 months. The royalty was fixed at 15 per cent.

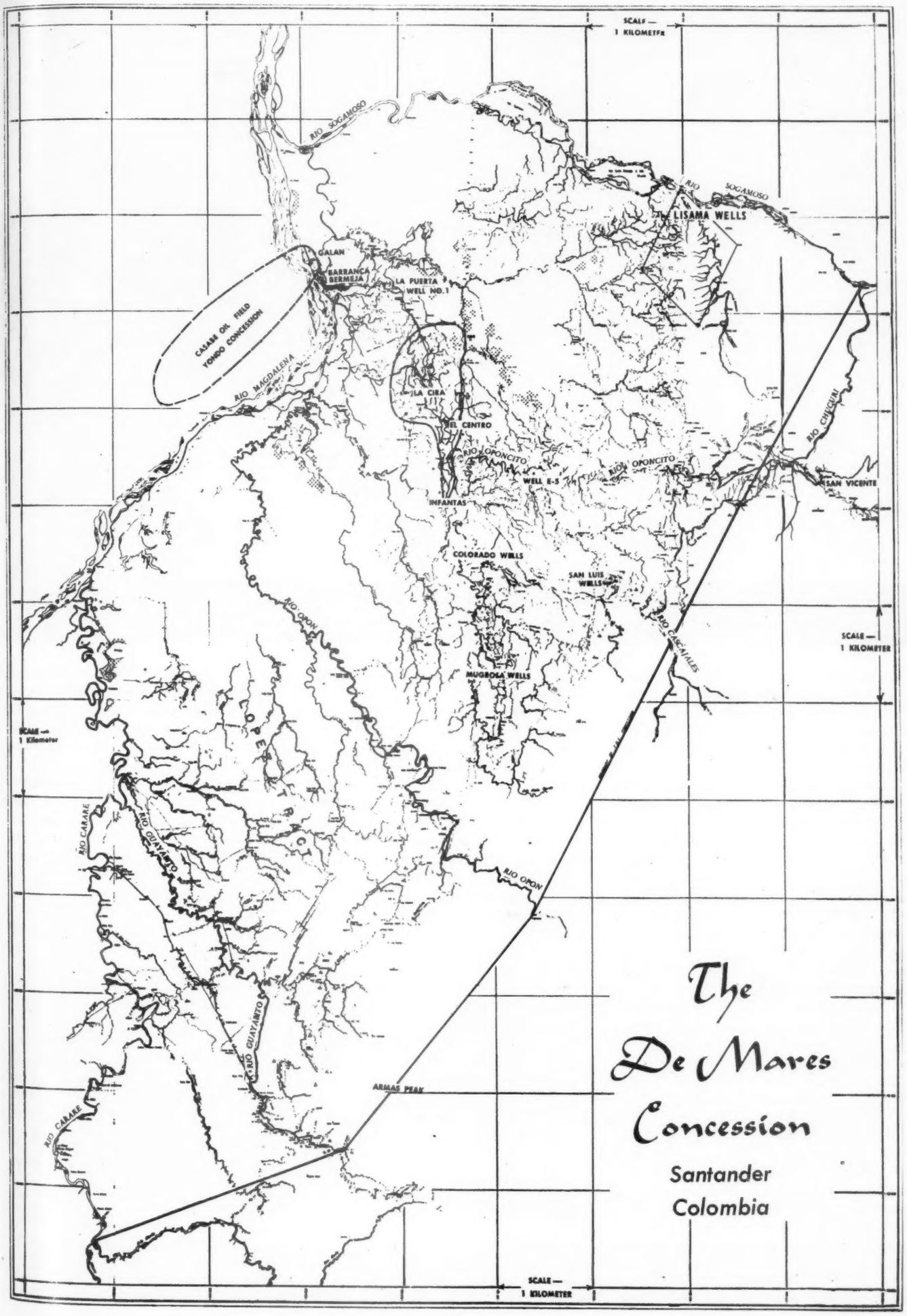
Justo M. de la Espriella y Cía. of Cartagena acquired a half interest in the concession on May 26, 1906.

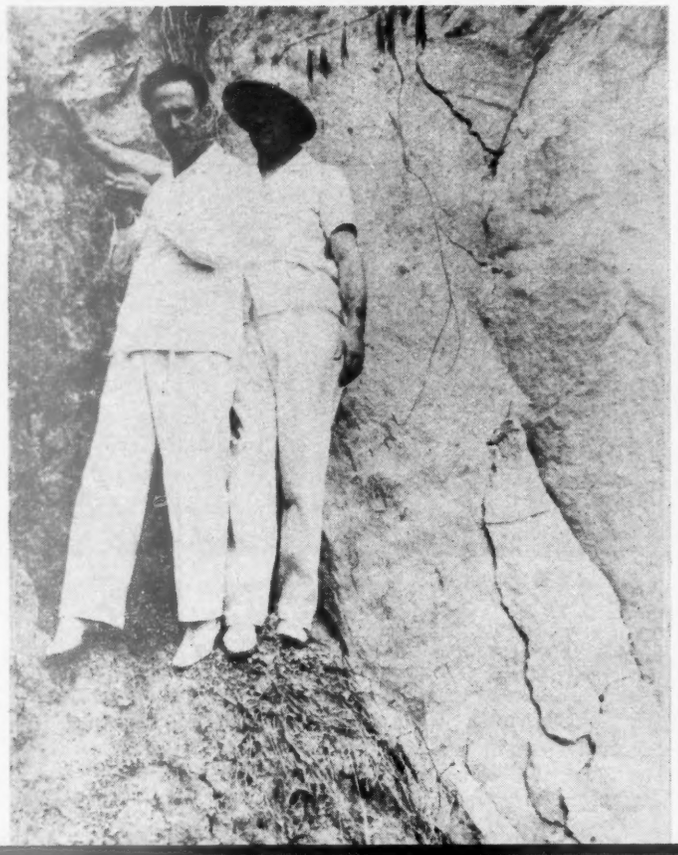
It appears that the 18 months period had elapsed without the required work being begun, for on October 22, 1909, the government revoked the contract. De Mares filed a plea for a 24-month extension. He had started a well from which he had obtained 50 gal of oil per day. An English syndicate had become sufficiently interested to make an investigation. Rain, disease, Indians, and political troubles had impeded progress. The government's refusal to reconsider its action was only another difficulty on the long trail leading to the beginnings of success with the reinstatement of the contract on May 17, 1915, with the provision that work should begin by June 25, 1916. Luciano Restrepo and John W. Leonard, acting as intermediaries, had brought the prospect to the attention of the Benedum-Trees interests of Pittsburgh, Pennsylvania.

Luciano Restrepo and John W. Leonard, engineer and geologist, made a statement on February 28, 1916, that opening of roads had been begun, that José Joaquín Bohórquez was exploring the Río Carare, and that on February 10, 1916, the S. S. Union had arrived at Barrancabermeja with 18 passengers, "the commission of engineers and capitalists charged with visiting the region of the Opón." A petition for a direct transfer of the concession having been rejected by the government, De Mares made a contract on May 17, 1916, with J. C. Trees, G. W. Crawford, and M. L. Benedum, who organized the Tropical Oil Company. In the records there exists an "Acta de Iniciación de los Trabajos de Exploración," sometimes referred to in subsequent court proceedings as the Acta de San Vicente, giving formal notice that the drilling of the first well was started on June 14, 1916, and attested by the Inspector of Police at Barrancabermeja and other witnesses.

A report written by Roberto De Mares in May, 1918, mentions some of the troubles that beset the early operations. The camp had been established on the north bank of the Río La Colorada at Infantas, but flood waters covered the buildings and the camp was moved to higher ground and named the Campo Americano. It was necessary to skid the combination rotary-standard rig and start a new hole. Well No. 2 was located on a hillside and the heavy rains of December, 1917, caused a slide "of more than 6000 cubic yards of earth" which engulfed the boilers and machinery. But on April 20, 1918, well No. 2 had gushed oil to the top of the derrick, a site for a refinery had been acquired at Barrancabermeja, and plans made for a pipe line from the wells to the refinery and thence on to the coast. The employees numbered about 125 and there were shops and camps at Infantas and Barrancabermeja. The marine department had, besides launches and canoes, a 50-ton steamboat, the Roberto Fulton. Telephone lines had been installed between the various camps and offices. A telegraph line was needed to connect with the government owned network at San Vicente de Chucurí, but the official in charge insisted that the wire and insulators were not of the proper size.

Dr. Jaime Toro at site of Infantas No. 1.


SCALE — 1 KILOMETER
RIO SOGAMOSO
LISAMA WELLS
GALAN
BARRANCA BERMEJA
LA PUERTA 1 WELL NO. 1
CASABE OIL FIELD
TONDO CONCESSION
RIO MAGDALENA
LA CIRA
EL CENTRO
RIO OPONCITO
WELL E-5
INFANTAS
COLORADO WELLS
SAN LUIS WELLS
RIO CHICAMI
SAN VICENTE
RIO CACATALES
RIO OPON
MUGROSA WELLS
RIO CARARE
RIO GUAYABITO
ARMAS PEAK
The De Mares Concession
Santander
Colombia



"Although," remarked Don Roberto, "they were perhaps superior to those used here . . . As a result here remains unused, equipment, wire and insulators sufficient for 200 miles, and the telegraph line is not built."

World War I was in progress, and, with the subsequent boom and depression, undoubtedly had some effect on the operations, not considering that they were in a tropical jungle over 300 miles in a direct line from the nearest convenient port of entry, and that the only means of communication was by boats on rivers subject to the seasonal variations of a tropical climate. Nevertheless, in 1918 three producing wells were completed.

Infantas well No. 1, which had been started on June 14, 1916, 11 days before the date of expiration of the reinstated contract, was situated on a hill about ½ kilometer north of the Río La Colorada and just west of the oil and gas seepages that mark the Infantas fault. This location has since been determined as latitude 6 deg 51 min 55.0 sec north, longitude 73 deg 45 min 48.8 sec west, and elevation above sea level of 441 ft. The first hole was lost at 860 ft. The combination rotary-standard rig was skidded, a new hole started on February 27, 1918, and completed on November 11, 1918, in the "C" zone at 1943 to 2280 ft with an initial production of 2000 bbl of 30 gravity oil.

However, the discovery well was Infantas No. 2, situated about 2 kilometers north of No. 1. Drilling had started on December 12, 1917, and on April 27, 1918, the well was completed in the "C" zone at 1531 to 1580 ft for 800 or 1000 bbl. This well, after being reworked several times, is still producing about 3 bbl of oil per day.

Infantas Well No. 3, about 300 meters southwest of No. 2, was drilled during the period October 15, 1918, to December 19, 1918, and completed in the "C" zone at 1009 to 1054 ft for 600 bbl.

In a contract dated August 25, 1919, in which the participants were Roberto De Mares, for himself and as representative of Justo M. de la Espriella y Cía., the Tropical Oil Company, and the National Government, it was set out that application had been made on April 9, 1919, to transfer the concession to the Tropical Oil Company, that permission had been given on August 23, 1919, and that the purpose of this new contract was to modify and clarify the contract of December 6, 1905, which was done forthwith in 22 articles. The new contract, among other provisions, called for a more definite designation of the eastern boundary of the concession "along the foot of the Cordillera Oriental"; a refinery to be built within 2 years and the crude oil and products to be marketed at the place of production at prices not to exceed those charged in the city of New York; the term of the contract to be for 30 years "from the date on which may begin the work of exploitation"; and the royalty to be 10 per cent.

Wells Drilled on the De Mares Concession 1916 to 1948, Inclusive

	Producers	Dry Holes	Total
Infantas—La Cira	1310	30	1340
Colorado (includes 1 gasser)	6	9	15
Galan (includes 2 producers in reserved zone)	5	—	5
La Puerta	—	1	1
San Luis (abandoned)	3	3	6
La Mugrosa (abandoned)	1	3	4
E-5 (10 kilometers east of Infantas)	—	1	1
	1325	47	1372

Control of the Tropical Oil Company was acquired in 1920 from the Benedum-Trees interests by the International Petroleum Company, Ltd., a subsidiary of Imperial Oil, Ltd. (In 1948 Standard Oil Company (New Jersey) purchased Imperial's stock in International).

After the difficulties of promotion and exploration had been surmounted, the inevitable conflict arose over the allocation of interests in the emoluments. It appears that Colonel Bo-

hórquez felt that he should have received a greater share of the rewards but the resulting lawsuit was resolved in favor of De Mares.

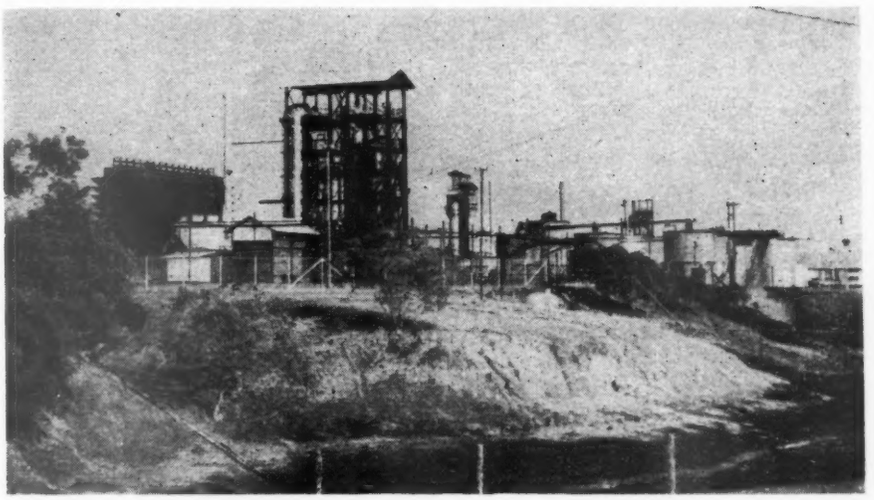
The completion of the refinery was delayed and on April 25, 1921, an extension of one year was asked by Tropical Oil Company. As a result there was issued a presidential executive order dated June 13, 1921, which not only granted the requested extension but also stated that the duration of the concession would be for 30 years from August 25, 1921.

In 1921 a road was built from Barrancabermeja to Infantas. Well No. 4 was the first to be drilled under the International management. It was started on October 25, 1921, and abandoned as a dry hole on July 19, 1922.

The refinery, with a capacity of 1400 bbl per day, began operations in February, 1922. This plant was processing 25,000 bbl per day in 1948.

Andian National Corporation, Ltd., and the government made a contract dated October 1, 1923, for the construction of a pipe line from the Infantas-La Cira field to Mamonal on the Caribbean coast just south of Cartagena. The first oil arrived at Mamonal on June 10, 1926.

In 1925, to cope with the increased activities connected with the development of the La Cira area, the main field camp was established at El Centro, 8 kilometers north of Infantas, and a meter gage railroad 28 kilometers in length was put into operation between the refinery at Barrancabermeja and El Centro.

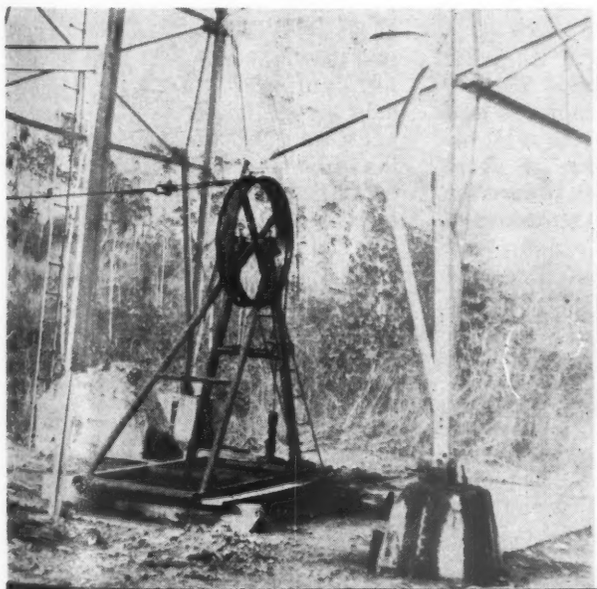


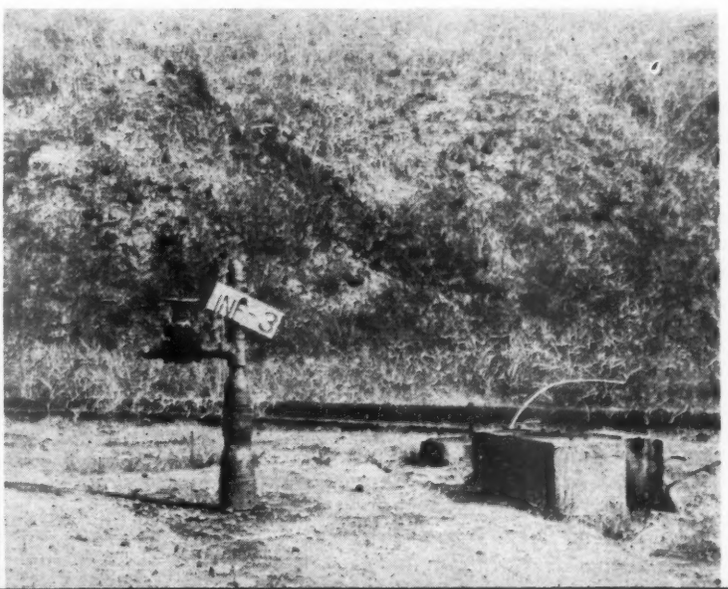
Tropical Oil Company refinery at Barranca-Bermeja.

Geological and geophysical work has been conducted on the concession over the years and most of the concession has been mapped. There are numerous oil and gas seepages along faults and crests of structures. Several structures have been drilled. Infantas-La Cira has produced 378,000,000 bbl of oil during the period 1918-1948, which is by far the greater part of the oil produced on the concession. Some production has been obtained from other areas. San Luis produced 7995 bbl during the years 1926-1929 and La Mugrosa produced 69,838 bbl in the period 1929-1931. Colorado has produced 250,450 bbl since 1928 and Galán has produced 123,039 bbl since 1945. Tropical Oil Company has drilled 1372 wells on the concession, of which 1325 have produced oil, 1 is a gasser, and 47 have been abandoned as dry holes.

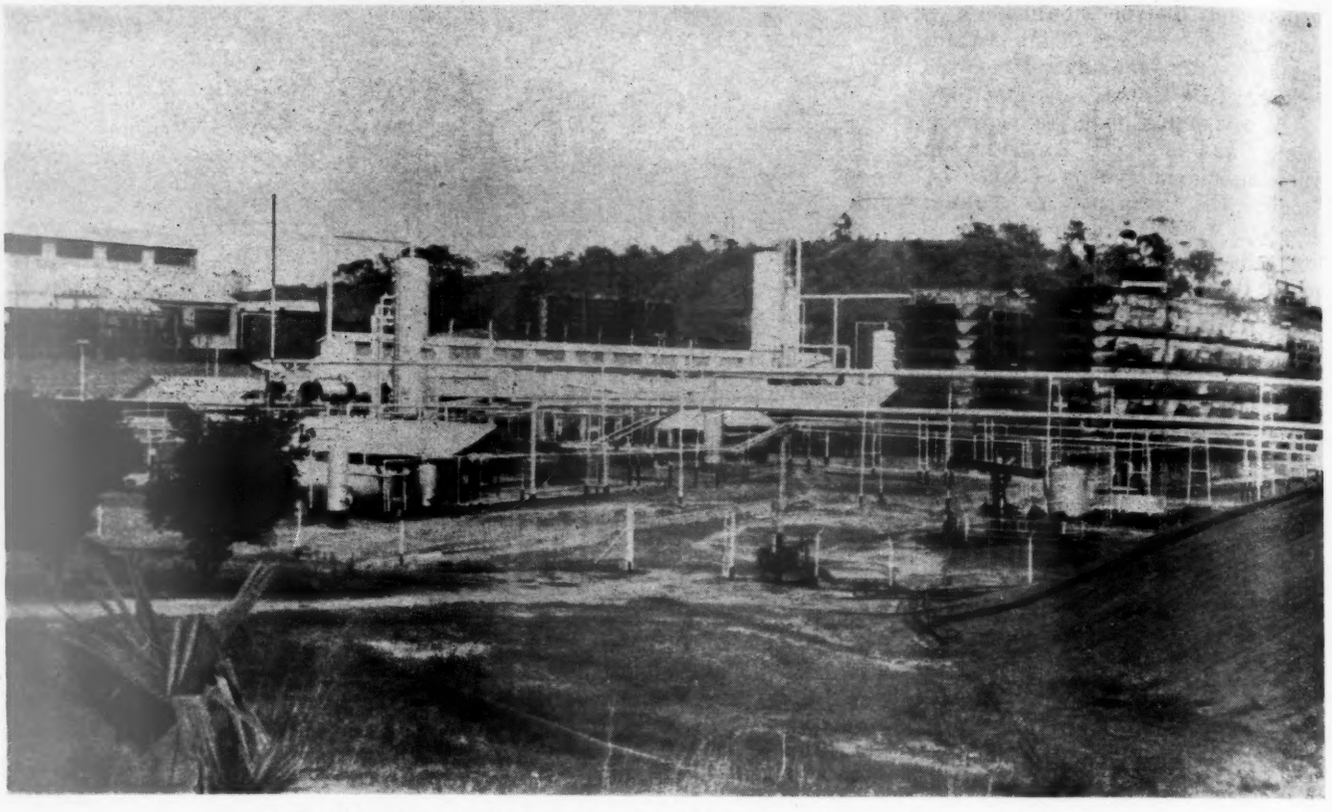
Currently (December, 1948) there are 1186 wells on the active list producing approximately 32,000 bbl of oil per day. At Colorado 5 wells produce 230 bbl per day and at Galán 3 wells are making 100 bbl per day. Infantas-La Cira has 1178 wells on the active list of which 963 wells are producing oil, the remainder being classified as 10 water injection wells, 45 gas injection wells, 156 high gas-oil ratio wells, and 4 wells being given cleanout or workover jobs.

Tropical Oil Company's producing and refining operations on the De Mares concession constitute one of the largest single business enterprises in Colombia. Facilities are provided to shelter, maintain and entertain, in health and in sickness, about 3000 employees and their families, estimated at 11,000 individuals. Some 3000 or 4000 "colonos" or squatters have settled in and around the pro-





Home-made wood jack at the Infantas La Cira oil field. Well No. 316 De Mares Concession, December, 1948.



Tropical's gasoline plant at El Centro. The power plant is shown on the left.

ducing areas and their clearing and burning of the tropical forest and other activities constitute a hazard and expense to the oil operations. Advanced labor and social laws accompanying the liberal trend of the times have proved difficult, tedious, and expensive of application to the needs and desires of a somewhat inefficient body of labor, poorly prepared to receive the multiple blessings of this "new" world.

The date of expiration became a matter of dispute, the government alleging that June 14, 1916, the start of the drilling on Infantas Well No. 1, began the 30-year term and Tropical Oil Company defending the executive order of June 13, 1921, which stated that the duration of the concession would be for 30 years from August 25, 1921. In September, 1944, the Supreme Court of Colombia decreed that August 25, 1951, would be the day that the De Mares Concession with "all of its works, buildings, machinery, equipment, tools, all exploitation materials, including the refinery and all means of communication, in the state in which they may be found," reverts to the Nation.

Infantas-La Cira Oil Field

The Infantas-La Cira oil field covers an area of 16,770 acres. The east side of the field is marked by the Infantas fault and the Infantas and San Antonio oil and gas seepages. The most southerly well is on the north bank of the Río La Colorada. The Infantas area extends north from this point in a narrow belt, widening gradually, though somewhat erratically, to a width of about 3 kilometers over a distance of 9 kilometers where it expands towards the west into the La Cira area, attaining a width of approximately 6½ kilometers and extending north an additional 9 kilometers.

The La Cira area was for some years considered a separate and distinct field, but the only distinction now made is that indicated by an arbitrarily drawn line beginning at about where the field widens out toward the west (near Well No. 640 northwest of El Centro) and thence running east and northeast to the eastern edge of the field north of the San Antonio seepages.

The first well to produce oil in the La Cira area was No. 58, which produced from the "A" zone in 1925 and was completed on April 26, 1926. Well No. 125 appears to have been the first La Cira producer in the "B" zone and in the "C" zone, its completion date being July 9, 1926.

The Infantas-La Cira oil field lies in the low hills bordering on and to the east of the lowlands of the Río Magdalena and the Río La Colorada. Well elevations in the field vary from 268 ft to 525 ft above sea level. The area was once covered with dense tropical forest but much of this has been removed in connection with the oil operations and the farming of "colonos" (squatters). From the east the Río Oponcito approaches to within 2½ kilometers of the central part of the Infantas area and there makes a significantly abrupt turn to the south to join the Río La Colorada at about 1½ kilometers east of the south end of the field. The Río La Colorada flows past the south end of the field and then turns northwest to enter the Río Magdalena.

Structurally, the main feature of the Infantas-La Cira oil field is the overthrust fault extending for a distance of about 16 kilometers along the east side of the producing area, gradually dying out or disappearing to the north and south. In the Infantas area "C" zone sands are exposed along the east side of the fault overlying "B" zone sands and clays. The maximum throw appears to be on the order of 2000 ft. The fault plane dips to the east at angles of about 50 or 60 deg. The Infantas oil seepages, extending north from the Río La Colorada for a distance of about 4 kilometers, and the San Antonio seepages, 8 to 10 kilometers north of the river and just to the east and northeast of the El Centro camp, mark the surface trend of the fault.

The "C" zone beds and the beds above the "C" zone east of the Infantas fault dip steeply to the east. The "B" zone and younger beds to the west of the fault dip to the west. All of the producing zones are exposed at the surface in the area of the field, entirely surrounded by younger beds that enclose them against the fault.

In the Infantas-La Cira field oil and gas is produced from more or less lenticular sands in the Chorro formation with a thickness of 750 ft ("C" zone), in the Mugrosa formation with a thickness of 1300 ft ("B" zone), and in the lower 1500 ft of the Colorado formation ("A" zone).

The "C" zone producing sands, which are the most prolific, underlie the entire field. Higher in the section, but not coextensive with the "C" sands or with each other, are the "B" sands, which have yielded about 10 per cent of the production, and the "A" sands, which account for about 1 per cent of the total production. In general the structural features of the field persist and can be mapped in all three zones.

Subsurface contouring on the top of the "C" zone within the producing limits of the field indicates that the highest part of the structure is in the Infantas area along the Infantas fault in the vicinity of wells Nos. 34 and 539 and approximately 3 kilometers north of the Río La Colorada. From this vicinity the top of the "C" zone dips to the south and west from elevations of about sea level to 2000 to 2600 ft below sea level. To the north and west, towards and through the La Cira area, the "C" zone descends to elevations as low as 3700 ft below sea level.

Throughout the field in the producing zones there are a number of normal faults that have a general east-west trend and close against the Infantas fault. These faults have throws of as much as 300 ft and they divide the field into a number of fault blocks or faulted areas which have been named or numbered for production statistical purposes.

The Infantas-La Cira structure may be described as a faulted anticline tilted downward towards the north. In the south-central part of the La Cira area there is a local high known as the Wheeler fold which rises to an elevation of 2100 ft below sea level on the top of the "C" zone. The Wheeler fold and the faults that cross it produce a sharp east dip of about 400 ft. This feature, in the early days of the development of the La Cira area, gave the mistaken impression that a major structural feature, then called the La Cira fault, separated the Infantas and La Cira areas.

The "B" zone production is found principally in the central part of the La Cira area on and around the Wheeler fold and to the east and south thereof, and in the north part of the Infantas area. In the Wheeler fold the "B" zone rises to 800 ft below sea level.

The "A' zone production is spotty and relatively unimportant. It is found principally on the Wheeler fold and in scattered wells elsewhere in the La Cira area and in 2 wells in the north part of Infantas. In the Wheeler fold the top of the "A" zone is 200 ft above sea level.

In the Infantas-La Cira oil field the total number of producing wells drilled to and including the year 1948 was 1310, of which 478 were in Infantas and 832 were in La Cira. The dry holes were 30 in number. No wells were drilled during the year 1948. The number of wells that were on production during the year 1948 was 988.

The tabulation "Producing Wells" shows the number of wells that were reported to have produced oil, regardless of amount, during each yearly period.

Some wells capable of producing were and are used as gas injection wells or water injection wells, or shut down on account of high gas-oil ratios or high water-oil ratios, or waiting on cleanout tools or awaiting reworking in higher sands or deepening to lower sands.

Most wells have been completed in sands in either the "A," "B," or "C" zones, but there are a number of dual completions.

Gas in the Infantas-La Cira Oil Field

All gas produced with oil is processed in one of the 5 gasoline plants in the field:

Plant—	Capacity
El Centro	16,620 Mcf per day
Infantas	10,385 Mcf per day
La Cira	16,942 Mcf per day
La Horca	9,000 Mcf per day
La Cira East	21,300 Mcf per day

The gas has an average of about 1.9 gal per thousand. The gasoline and LPG products recovered are used in part as motor fuel for company vehicles, or pumped to the refinery at Barrancabermeja through a special 3-in. line, or mixed with crude and delivered to the Andian pipe line.

The residue gas is distributed for domestic and industrial use in camps and plants on the concession and for use in the gas injection wells.

The production of liquid petroleum products from gas for the 1927-1948 period is estimated at 14,510,185 bbl.

Infantas-La Cira Oil Field Producing Wells

Year	Infantas	La Cira	Total
1918 } 1921 }	3	—	3
1922	6	—	6
1923	13	—	13
1924	29	—	29
1925	68	1	69
1926	126	9	135
1927	185	34	219
1928	248	83	331
1929	304	134	438
1930	386	153	539
1931	395	179	574
1932	390	175	565
1933	344	183	527
1934	369	188	557
1935	326	208	534
1936	324	263	587
1937	325	338	663
1938	324	442	766
1939	313	536	849
1940	302	596	898
1941	307	610	917
1942	308	594	902
1943	313	561	874
1944	310	610	920
1945	308	616	924
1946	261	646	907
1947	276	717	993
1948	289	699	988
Total number of producing wells drilled	478	832	1,310
Dry holes drilled	19	11	30

Water in the Infantas-La Cira Oil Field

Salt water is produced in small quantity principally from wells along the western and northern edges of the field. Some of this water is undoubtedly water injected into the sands in the secondary recovery projects.

The oil-water emulsion is pumped to the La Cira high cold-test oil dehydration and desalting plant (in kilometer block 14N-2W) or to the El Centro low cold-test oil dehydration plant (in kilometer block 9N-1W), where after treatment the oil is delivered to the pipe line.

Some of the salt water from these plants is used in water-injection wells.

Salt content of the oil is as high as 2200 lb per thousand barrels of oil, the average being about 1800 lb. Treatment in the plants reduces the salt content to about 14 lb per thousand barrels of oil.

Secondary Recovery in the Infantas-La Cira Oil Field

Secondary recovery projects have been conducted since 1928. At the present time (December, 1948) gas is being injected in 19 La Cira "C" zone wells and 26 Infantas "C" zone wells, and water into 9 La Cira "C" zone wells and into one La Cira "B-C" zone well.

The Ranney oil-mining process was given some consideration about 1927. Several diamond drill holes were put down to the "A" sand on the Wheeler fold. There is still on the junk pile at El Centro a mine-hoist drum and dump bucket.

Colorado Oil and Gas Field

The Colorado field is situated in kilometer blocks 4 and 5 E and 7 to

"Midget Angle" AIR-TESTS

NEAR JERSEY CITY within clear sight of New York's skyscrapers, the vital job of air-testing a 22 mile section of mainline 30″ and 26″ gas pipeline is well under way. And what a gigantic respohsibility this is . . . checking against possible defects or damage that could well result in serious leaks or explosions once the gas is turned on to serve this densely populated metropolis.

NEW AND UNIQUE is the means which Fish Constructors, Inc. selected to make this pressure test . . . a Clark bottled propane-driven, 6-cylinder, Midget Angle Air Compressor . . . a completely self-contained, skid-mounted package.

TESTING OF THIS 22-MILE SECTION of mainline pipeline is conducted in ½ to 5-mile segments already buried. Connected to the MA unit by rubber hose, the line is brought up to 850 PSI by predetermined increments, the compressor then shut off and the pressure drop plotted against an ideal section.

THE MA WAS SELECTED FOR THE JOB because of inherent, perfect balance . . . permitting it to be set down anywhere, without need of special foundation or fastening . . . a feat made possible by the mounting of each compressor cylinder and each scavenging pump on opposing sides of the crankcase, thereby eliminating all shaking forces.

ANOTHER INFLUENCING FACTOR was the use of propane . . . not only because it's a cleaner burning fuel than gasoline or diesel oil, but because the MA operates also on natural gas . . . mighty important for future use or ultimate resale.

WIDELY KNOWN AS A "PACKAGED UNIT," the MA comes equipped to function as a completely self-contained compressor station . . . including scrubbers, starting air compressor, oil coolers, gas coolers, propane bottle rack and radiator (Clarkooler) which can be set up to operate with prevailing winds from any direction, thereby eliminating dangers of excessive temperatures.

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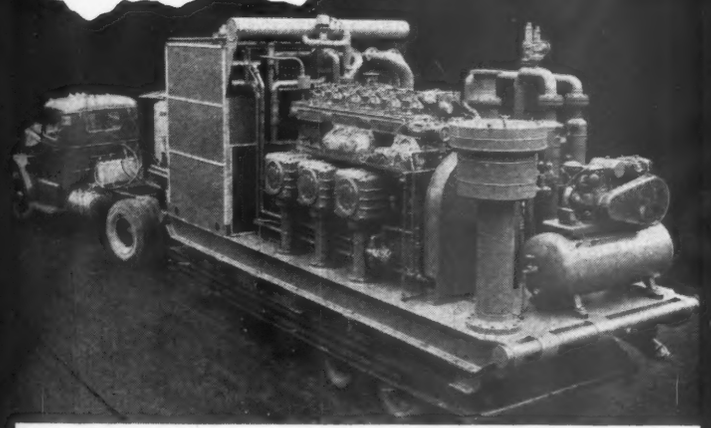
SEE the difference in . . .

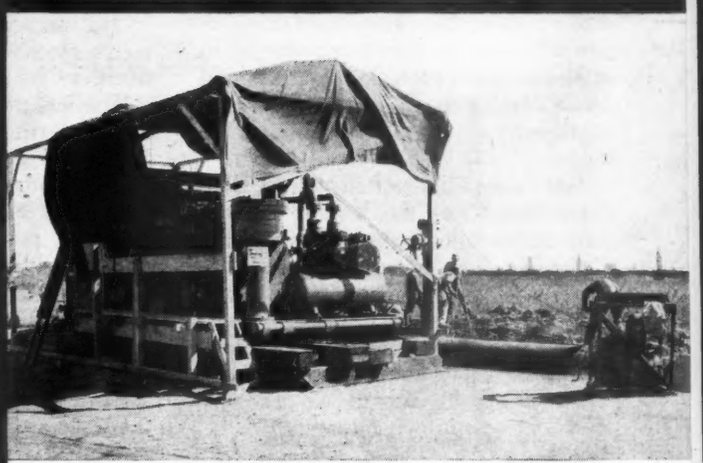
NEW 30" GAS PIPELINE

while New Yorkers move about in complete safety

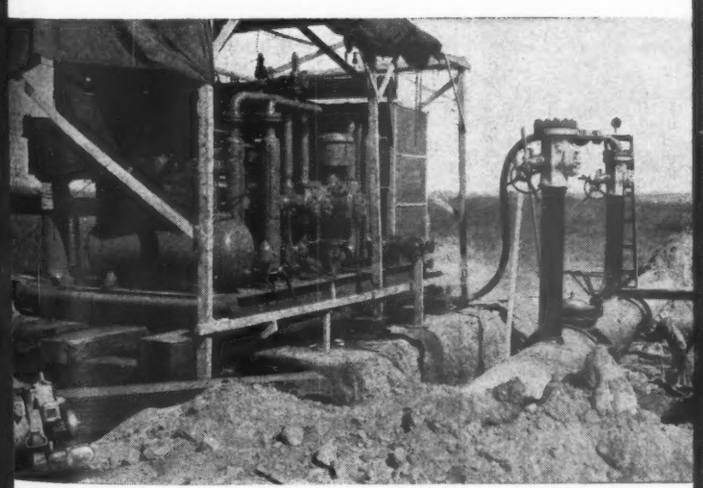
Portable, skid-mounted, bottled propane-driven compressor brings new security to densely populated areas



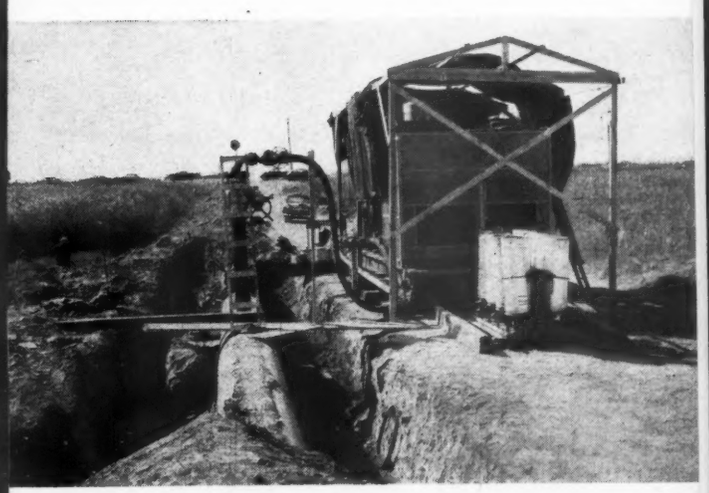
Leaving the Clark plant. Destination: Jersey Meadows.



Testing in the shadows of famed skyscrapers. Typical field set-up.



No foundation used. MA-6 merely rests on timbers, or remains on trailer, as desired.



Alongside line, already buried for testing. Propane bottles held upside down in rack, so that gas pressure forces liquid propane to expansion valve on top of radiator.

COMPRESSORS

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10 S, that is, about 8 to 10 kilometers southeast of the south end of the Infantas area.

The structure is described as a narrow overturned fold with a north-south axis. It is said that it is not an overthrust fault.

At Colorado exploration began in 1923 and 15 wells have been drilled. In the north part of the field there is a gas well, No. 7, in the "C" zone. At present this well is shut in. In the south part of the field there are 5 oil wells, drilled in 1945 and 1946, Nos. 9, 10, 11, 20 and 21, producing on the pump from the "B" and "C" zones at a rate of about 230 bbl of oil per day (December, 1948). The total field production to December 31, 1948, has been 250,450 bbl.

Galan Oil Field

The Galán oil field is situated on the east side of the Río Magdalena, just north of the Tropical Oil Company refinery at Barrancabermeja, in kilometer blocks 24, 25 and 26 N and 15 W. Galán is in fact the extreme northeastern part of the Casabe oil field.

The Compañía de Petróleo El Cóndor (Shell) has the Yondó Concession, which is located on the west side of the Río Magdalena opposite the De Mares Concession. The Casabe structure on the Yondó Concession was discovered by geophysical methods. There are no surface indications or workable outcrops. Casabe Well No. 1 was completed in October, 1941. When it became apparent that the field would extend northeast under the Río Magdalena, drilling was started at Galán on the east side of the river, and in 1945 and 1946 five wells were completed in the "A" zone. It is alleged that two of these five wells are within the government's 100 meter reserved zone along the river and these two wells are now closed in. The total field production to December 31, 1948, has been 123,039 bbl. Currently (December, 1948) the 3 producing wells are pumping about 100 bbl of oil per day.

System of Coordinates

The Tropical Oil Company has a system of coordinates in connection with its surveying and mapping activities in which Infantas Well No. 1 is the zero point from which kilometer blocks are laid off in all directions.

The location of Infantas No. 1 has been determined by astronomical observations as latitude 6 deg 51 min 55.0 sec north and longitude 73 deg 45 min 48.8 sec west.

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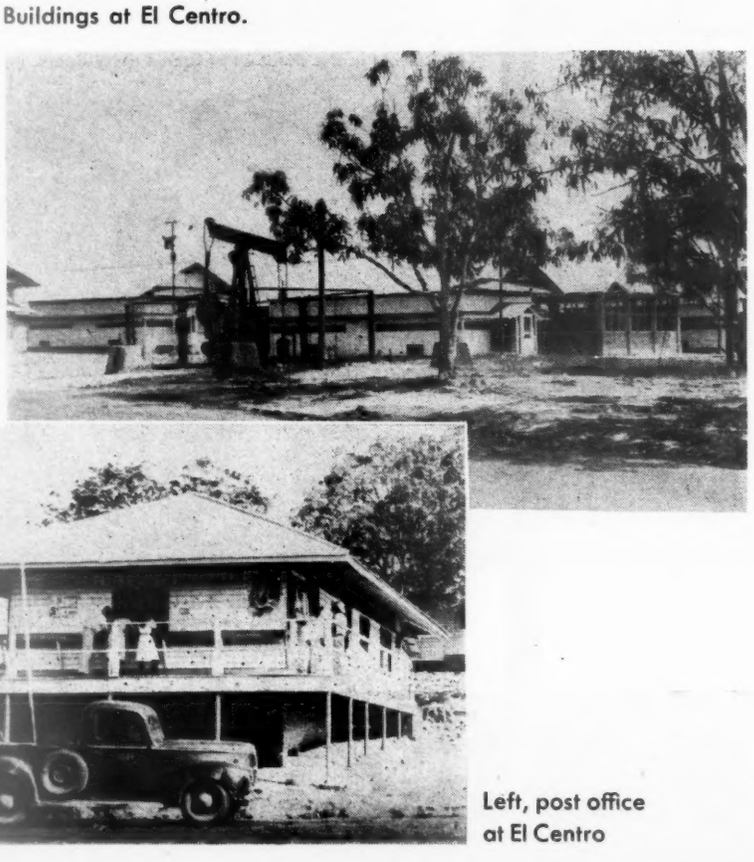
Buildings at El Centro.



Left, post office at El Centro

A U.S. View of Oil Conditions in Europe

Fritz Huntsinger visited oil and gas fields and manufacturing centers; he discovered some oil tool items in which German factories excelled but found field operations inefficient

An extremely interesting report on the heavy industries and oilfield installations of Europe, was given by Fritz Huntsinger, president of Ventura Tool Company, to the members of AIME Juniors, Pacific Petroleum Section, at a meeting in the Rio Hondo Club, Downey, California. The speaker had recently completed a tour of Europe, which was originally intended to be just a visit with relatives and boyhood friends but quickly developed into a series of inspections that included many *verboten* plants and places and provided him with a rare opportunity to see at first hand the prevailing conditions across the Atlantic.

Through a brother-in-law who manages a Swiss plant with some 4200 employees, the visitor was enabled to gain access to industrial units in Switzerland, France, Italy, Holland, Belgium, and Luxembourg, and was extended the additional privilege of visiting both the East and West Occupation Zones in Germany. He returns with a highly significant comparison of prices that should make fine ammunition, if any more is needed, to carry the free enterprise story to the more stubborn adherents of state socialism. Due to his facility in the use of the European languages and the industrial standing of his relatives over there, Huntsinger was accorded an insight into conditions generally that is given to few Americans.

In Switzerland he visited a number of plants in the fine machinery industry, for which the Swiss are justly famous and was much impressed. He was particularly interested in the modern electrical power system that the country has created. All new telephones and high-power lines are carried in underground conduit, high tension lines up to 150,000 volts having been buried in this fashion. One power plant supplying this transmission system was described as having generating equipment in a cavern, 285 ft long, 90 ft wide, and 84 ft high, that was blasted from solid granite. Two penstocks, drilled and tunneled through the mountain, tap lakes at 10,000 ft elevation to supply the 160,000 kw plant. From the exterior nothing of this tremendous installation is visible but a door in the cliff face. Protection against air attack was, of course, the primary reason for this type of underground construction.

The importance to the Swiss of such protection was highlighted by Huntsinger in his description of the City of Wesel, which is near the point where Patton crossed the Rhine River. This city was bombed by the British in 1943 and again by American planes in 1945. In March 1945 approaching American forces asked three times that it be declared an open city. After the third German refusal B-29 planes spent 18 minutes over the city and 50,000 of the city's 55,000 population were killed. Today the total destruction is still evident with many families still living in the cellars of their bombed out homes.

As a side light Huntsinger described the *autobahn*, which he declared to be the most beautiful highway over which he has ever travelled. It is constructed of re-inforced concrete 12 in. thick with two lanes of traffic in each direction. This construction is so sturdy that even the heavy military and tank traffic during the war has not damaged the highway. Every 20 kilometers, there is a service station, one on each side of the highway; and every 40 kilometers, there is a restaurant and a place to spend the night. Every 5 kilometers there is a turn off which leads to a parking area some 100 yards off the highway where picnic facilities are available. Of interest to the Americans are the laws governing use of the autobahn, which prohibit throwing refuse from vehicles and provide for maintenance of a cruising speed.

This article is taken from an address by Fred Huntsinger, who has a wide knowledge of the oil industry and oil equipment manufacture. A thoroughly competent observer, he contributes a highly interesting report of the European picture, especially in regard to oil operations and oil tools.

Drilling in Germany

From Switzerland Huntsinger travelled through Holland to the German City of Celle, which he described as the oil center of North Germany. He had planned to devote three days to a tour of the area, but due to the insistence of oil operators, he remained three weeks. Their feeling is apparently that an American can wave some magic wand and solve all their problems. They were insistent that Huntsinger visit each of their operations and make such suggestions as he saw fit. Their general problem is that they lag very far behind the United States in methods and equipment. Considerable trouble was experienced with twistoffs, which Huntsinger declared were due to low grade drill pipe and improperly designed tool joints. While some Hughes and Reed joints were beginning to appear, the Germans still cannot manufacture high grade drill pipe and are limited to grade D specifications.

Huntsinger was impressed, however, with the volume of drilling activity. Some 138 drilling rigs were in operation in Germany at the time of his visit. Many of these were operated by American oil companies, including Gulf, The Texas Company, Standard of California, Socony Vacuum, and Shell. Production is shallow, usually between 3000 and 4500 ft and limited by the quality of German drilling equipment to possibly 5000 ft. Huntsinger noted, however, that quite a little American equipment can now be found in European operations.

Oil Tool Factory

When still in Celle, he toured the plant of Salzgitter, the largest oil tool manufacturing company in Germany. He was tremendously impressed by

their research program and their many new developments. Due to the fact that German patents are not honored in the United States, the plant management was extremely cautious about allowing Huntsinger to see certain of their new products and, in fact, did not permit him to enter several departments. He did, however, observe the manufacture of a revolutionary new derrick, fabricated from special shapes of high alloy steel. This derrick was described as comparable to our standard 136-ft derrick, but 30 per cent stronger and 13,000 lb less in weight. The interesting feature was that the increments of the derrick telescope so that the complete unit will fit into two small packing boxes for shipment. It was possibly this derrick and other developments in this plant that prompted Huntsinger to summarize the German oil industry as being 10 years behind us with 90 per cent of their equipment and 10 years ahead with the remaining 10 per cent.

Oil Mining

Near Hanover, Huntsinger visited the Elwerat oil mine at Mudem. At this installation, oil of 12-14 gravity is being produced from a mine 900 ft deep. The operation is conducted on several levels by drilling holes back into the productive strata and allowing the oil to flow into pits. The oil so collected is then pumped in stages to the surface where it is refined and shipped. The operation requires 1400 men and is extremely costly, particularly due to the excessive amount of sand and other foreign material, which must be cleaned from the oil.

The Industrial Ruhr

From Northern Germany, Huntsinger travelled south to the great industrial area in the Ruhr. He described the Ruhr as the most concentrated area of heavy industry in the world. Compared to the Ruhr, Pittsburg or the Ohio Valley are like an olive in the center of a pie.

Huntsinger was able to tour several of the large plants in the area. One of these, the United Steel Works, was described as the most modern steel plant in the world. Under construction from 1931 through 1938, it covered 22 square miles and included 18 blast furnaces. Housing was provided for 345,000 employees. Fabrication halls were of open center construction one mile in length. There were 16 such halls 4 in line and 4 abreast. All piping and transmission lines were underground with 4-lane highways running overhead through the plant.

The iron ore beds are adjacent to the plant and were systematically laid out with automatic conveying systems feeding the ore to the furnaces. With an adequate coal supply near at hand, it was estimated that the plant could operate for 80 years at the World War II consumption rate before exhausting its raw materials. Huntsinger did not elaborate on the present condition of the plant, but noted that much of the equipment was being removed or destroyed by the British under the dismantling program.

Huntsinger also toured the Mannesman Tube mill in the Ruhr. He described the mills as the ultimate for tubular goods fabrication. They are laid out in long narrow bays and the metal is processed through the various stages in a straight line. Catwalks are provided above the production line so that you can walk along and view each stage of the operation.

It was in this plant that Huntsinger noted the newest and most modern of the mills being torn out by British occupation authorities under the dismantling program. Querying plant management on their seeming lack of concern, he was advised that they had already laid out an even more modern and improved mill to be constructed with ECA funds as soon as the British dismantling was completed.

At Mullheim on the Ruhr River, Huntsinger visited the plant of Haniel and Lueg, one of the largest European suppliers of oil field equipment. This plant prior to the war employed some 3800 employees but during Huntsinger's visit, there were but 120 persons employed. Their work week is 6 days on a 10-hour-a-day shift. The long week is encouraged by their strong union organizations in what Huntsinger described as a unified effort to produce cheaper and more efficiently in an effort to regain independence.

One of the newer developments in the Haniel and Lueg plant was a revotionary torque converter, which the management refused to discuss as the United States does not honor German patents. Huntsinger later saw this converter in operation with one diesel engine powering a drilling rig near Hanover. He described it as an apparently perfect power transmission medium with no observable whine or speeding up with changes in loads.

Huntsinger was also impressed with the rapid strides being made with inspection equipment for tubular goods and steel. He described equipment that can give spot check hardness readings on drill collars coming out of the hole to .240 in. in depth in 8 sec. He observed one inspection of a hollow turbine shaft 10 in. in diameter with 3 in. walls where a flaw was precisely located and later proved by cutting through the shaft. In general their inspection instruments are 10 years ahead of ours, due to the fact that they were able to start out from scratch after the war and build new equipment without amortizing the old.

As a final insight into American versus British occupation, Huntsinger described one plant where he was particularly impressed by the brand new American machine tools with which it was completely equipped. Discussion with plant management brought out the fact that the plant was in an area, which had alternated between British and American control. When under British control, the equipment had been removed and, for lack of better disposition, stored in a large shed on the premises. After return to American control the plant was put back into operation but with completely new equipment financed by ECA, due to British control over the old tools, which Huntsinger observed still stored in the shed.

Huntsinger concluded his talk with a discussion on the current conditions in East and West Germany. He presented the following wage and cost of living comparison for the two zones with the caution that some of the items, while priced are often not available.

Item	East Berlin	West Berlin
2 lb bread	$ 1.60	$ .80
1 lb butter	12.00	2.60
1 lb margarine	7.00	.70
1 lb sugar	6.00	.59
3 oz chocolate	12.00	.80
1 lb filet steak	21.00	2.50
Man's shirt	80.00	10.00
Lady's blouse	87.00	15.00
Man's suit	$ 350-$700	80.00
Shoes	$ 150-$300	$ 25-$30
Sewing machine	$1600	$150
Rentals of:		
Unfurnished 3 room apartment	$ 140-$160/mo.	$ 60/mo.
Unfurnished 4 room apartment	$ 180-$230/mo.	$ 75-$90/mo.
Wages of:		
Average wage earner	$ 1.40/hr.	$ 1.20/hr.
Engineer's salary	$ 420/mo.	$350/mo.
Chief engineer's salary	$ 800/mo.	$650/mo.

He noted that East Germans may travel to West Germany, but that they are not permitted to make purchases; a condition that gives rise to considerable smuggling and bribing of Russian border guards. There are also many cases of East Germans leaving homes and belongings behind to escape at night to the West zone. An illustration of this is the case of the Zeiss plant in the East zone, which shortly after the war had 5000 employees, but which in the past few years has lost all but 800 to the West. This forced Zeiss management to erect an ECA plant in the West zone. Huntsinger concluded his discussion with a statement on the general apathy of the German people toward rearmament and the high cost to them of the occupation. * * *

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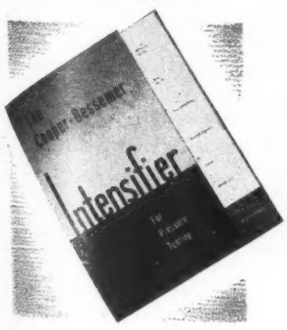

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OIL IN THE FAR EAST*

WILLIAM E. V. ABRAHAM†

HERE, in Los Angeles, I hope that I may use a very broad definition of the Far East to include all the world that lies east of the Urals and the Persian Gulf and (except for a few small islands) west of the Americas. This area will, therefore, include, on the west, Afghanistan, Pakistan, and India; and, on the east, Japan—and I am including also Australasia.

This huge area, about one-third of the globe, includes some 35 per cent of the world's land surface and more than half of the world's population; and the relationship between the oil there produced or likely to be produced and the present and probable future oil requirements cannot fail to be of interest.

Consumption

Most of us are familiar with the astonishing fact that (roughly speaking) two-thirds of the world's oil production is consumed by 150 million Americans and one-third by the 2000 million inhabitants of the rest of the world. We are also accustomed to state as a generalization that the Far East is *the* great unsaturated oil market of the world. In spite of this, it may come as a surprise to some of us that the half of the population that lives between the Urals-Persian Gulf and the Pacific consumes less than one-twentieth of total world consumption.

The largest consumers are shown in Table 1.

The total Far East consumption of about 120 million barrels represents less than 5 gal per year per head of population, as compared with a corresponding figure for the U.S.A. of almost 600 gal. It is, therefore, hardly too much to say that (with certain exceptions such as Australasia) the Far East as defined in this paper has hardly begun to use oil in the sense that it is used in America. If every human being between the Urals and Pacific consumed, on the average, even one-tenth as much as an average person in the U.S.A., the annual Far East consumption (if and when the oil could be made available) would jump from about 120 million to about 1300 million barrels.

Production

One might have though that the very small present demand (in relation not only to the population but to square mileage involved) could have been met by oil produced from different places within this huge area. Such is not the case. Production from all sources between the Urals-Persian Gulf and the Americas amounts to not much more than one-fortieth of total world production. The main producing countries are:

	Millions of U. S. barrels (1949)
Indonesia	42
British Borneo	25
Asiatic Russia (including Sakhalin)	17
Remainder	7
	91

The first question that must strike anyone on seeing these figures is whether this very small oil production from such a very large part of the earth's surface is due fundamentally to lack of rich oil deposits of to a failure, for whatever reason, up to the present to explore the possibilities at all thoroughly. I can best answer this by dealing with the different areas separately; and for convenience I shall deal first with the more southerly countries—going from west to east and leaving the large tracts of Asiatic Russia and China to be dealt with last.

Afghanistan

No oil is produced; but oil indications have been reported from the northern provinces, immediately to the north of which there are the small Russian oil fields of the Ferghana valley. So far no tests have been drilled and any developments are likely to come from the Russian side. Geological investigations have not suggested that there are any prospects of obtaining oil in the more southerly part of the country bordering Pakistan.

Pakistan, India, and Ceylon

As we pass from the Persian Gulf into the Gulf of Oman, we also pass abruptly and surprisingly from the Middle East petroleum region into an entirely different geological province both as regards lithology and type of folding; and this change is strikingly reflected in relatively poor oil discoveries and prospects.

Oil of Eocene age is produced in a few small oil fields (Khaur, Dhulian, Balkassar) in the province of Punjab, in western Pakistan; and more of these small fields of the order of 5 million

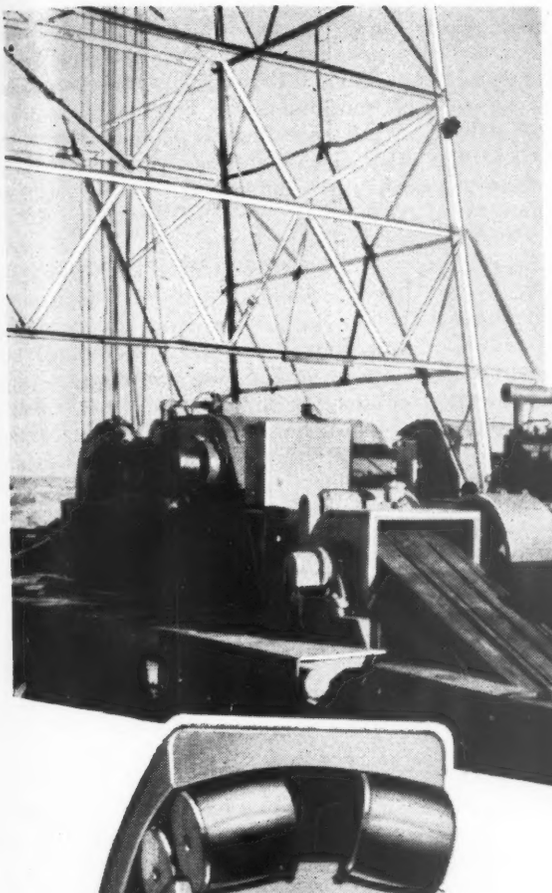
Table 1

	Area (Thousands of square miles)	Population (millions)	Estimated 1949 consumption (millions of barrels)	Annual oil consumption per head of population (U. S. gallons)
Australasia	3,079	10	32	134.4
Asiatic Russia	8,245	42	17*	17.0
India, Pakistan and Ceylon	1,930	416	28	2.8
Japan	263	78	11	5.9
Siam and Malaya	248	23	7	12.8
Philippines	115	19	10	22.1
China, Tibet, and Mongolia	4,314	467	7	0.6
Remainder	1,582	137	10	3.1
	19,776	1,192	122**	4.3?

* No estimate available. The figure given here is the estimated production. Consumption may be somewhat larger than this.
** Consumption figures in this table exclude bunkers.

*Presented before a Division of Production Group Session during the 30th Annual Meeting of the American Petroleum Institute, in the Biltmore Hotel, Los Angeles California, November 15, 1950.

†Joint managing director, The Burmah Oil Company, Ltd., London, England.



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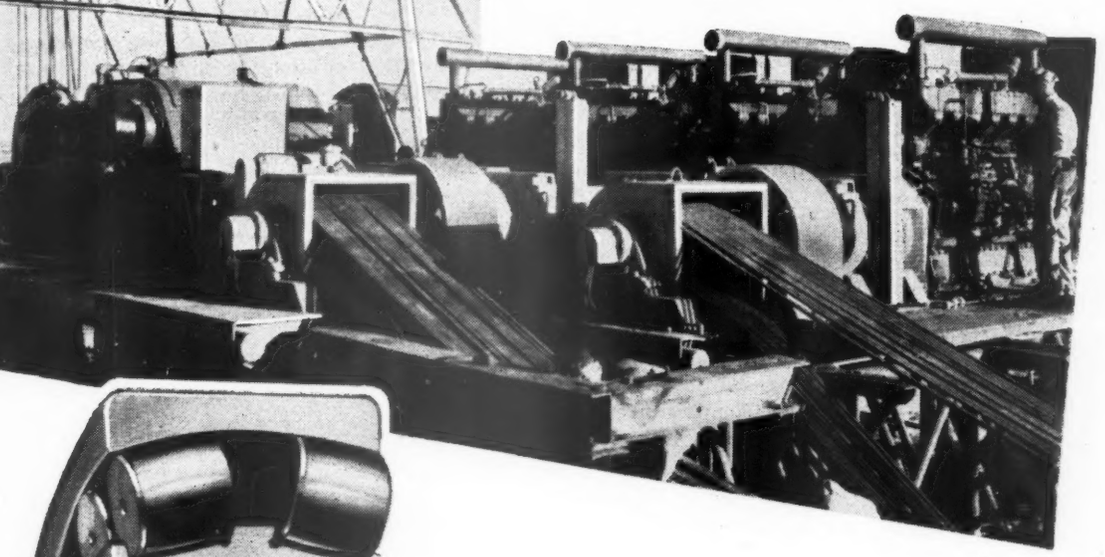

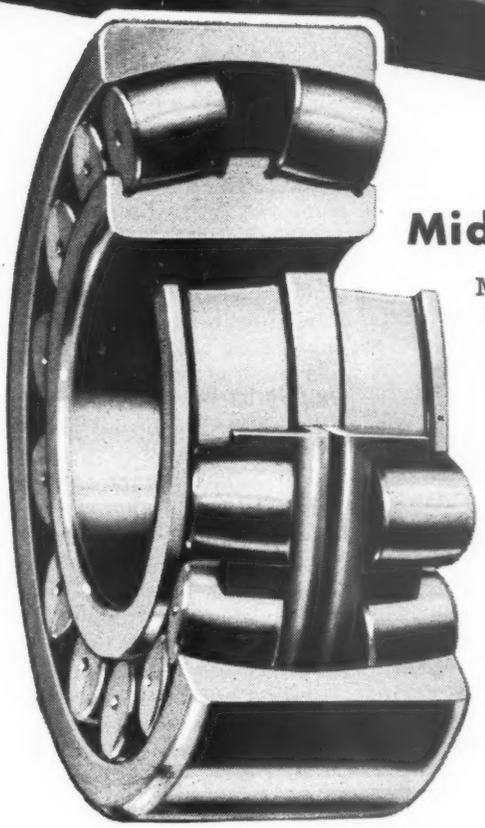

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barrels each may remain to be discovered. Further west in Baluchistan there appear to be possibilities of somewhat bigger oil fields and preparations for testing are in hand. The Sind valley near Karachi has been carefully surveyed geophysically but a recent deep test in this region gave completely negative results.

In the main mass of penisular India and in Ceylon, no oil possibilities exist. North of Calcutta and the Ganges delta has been surveyed geophysically—with disappointing results. Farther east, in eastern Pakistan and the adjoining part of India, there are possibilities of small oil fields. Still farther to the northeast, the Digboi oil field, now 60 years old, has produced some 5000 bbl per day for the past 20 years from rocks of Miocene age. A large number of test wells have been drilled without proving oil in any neighboring structures but there is still a slight hope that some further oil will be discovered. Aggregate production to date from the whole of the sub-continent of India plus Pakistan is only about 60 million barrels. All oil so far discovered is processed in small local refineries.

Burma

Burma has produced to date some 250 million barrels of oil, mainly from the 2 fields of Chauk and Yenangyaung, of which the latter passed its peak many years ago. The oil rocks are of Miocene and Oligocene age. Oil was formerly piped some 300 miles from the oil fields for refining near Rangoon but political unrest has made impossible repair and operation of the pipe line. As a result work on the rebuilding of the Syriam refinery near Rangoon has stopped and oil production, for local marketing, is less than 2000 bbl per day, all from the Chauk field.

Prior to the war many test wells were drilled in the hope of discovering new fields in Burma, but all without any success; and, although there is still some testing to be done, when political conditions permit, it seems on the whole unlikely that Burma's production rate will be in the future as high as the prewar rate of about 20,000 bbl per day.

Siam and Malaya

The stratigraphic sequence in these countries is essentially Palaeozoic, Triassic, and Pleistocene. Oil shales exist but the chances of obtaining crude oil are nil.

French Indo-China

Formations younger than the Triassic are here dominantly continental; and, although some oil indications have been reported, no significant accumulations are to be expected.

Sumatra

Oil production in Sumatra dates from 1893. The oil occurs in rocks of Pliocene and Miocene age; and the oil basin, stretching all the way along the eastern coast of the island, can be considered in terms of three separate sub-basins.

In North Sumatra 12 fields have produced oil in commercial quantities, total production to date being almost 160 million barrels. The oil used to be refined locally at Pangkalan Brandan; but this refinery was completely destroyed during and after the war and the political situation has so far prevented resumption of normal production and refining operations in this part of the island.

Oil is present also in Middle Sumatra; but exploration is difficult because of swamps and Quaternary plains, and fields are still in an early stage of development. A small field proved prewar at Lirik will probably be worth 7500 bbl per day. Another prewar discovery not yet developed is at Minas.

In South Sumatra 43 fields have yielded a total production of almost 475 million barrels. Rehabilitation since the war has in this area been so successful that 1950 production will exceed the prewar level of 85,000 bbl per day. Exploration has been resumed. South Sumatra oil is processed in two refineries at Pladju and Sungei Gerong (near Palembang).

Java

Oil occurs in the Pliocene and Miocene, and production in Java dates back to 1895. The principal fields—most prominent of which are Kawengan, Ledok, Nglobo, and Lidah—are concentrated within a rather small area in the eastern part of the island, where a cumulative production of almost 120 million barrels has been obtained.

Prewar production was about 6 million barrels per year; but political unrest has retarded rehabilitation, and 1949 production was only about half a million barrels. This was refined in a small unit in Surabaja, and used for local consumption.

Extensive exploration, carried out before the war in the western part of Java, has not yielded any promising results.

Indonesian Borneo

Oil activities on the east coast of Borneo started in 1897; and production from Pliocene and Miocene strata aggregates to date almost 430 million barrels—chiefly from the fields of Sanga Sanga, Sambodja, and Tarakan. Production from existing fields is now on the decline but exploration is continuing.

All East Borneo production except that from Tarakan, which is marketable as produced, is refined at Balikpapan.

Remainder of Indonesia

Oil production in the islands between Borneo and New Guinea up to now has been very small and the chances of obtaining any appreciable production in the future are remote.

The island of Ceram produced between 1897 and 1941 a total of about 8 million barrels from Pliocene and Triassic formations; but activity there ceased after the war. The island of Buton yields asphaltic bitumen.

British Borneo

Miocene production from the oil field of Seria, on the northwest coast of British Borneo, has increased from a prewar figure of about 15,000 bbl per day to almost 70,000 bbl per day in 1949 and this is now the most promising individual oil field in the whole of the East Indian archipelago. Oil is refined in part locally (at Lutong) and the remainder is shipped to other refineries. Seria has been producing only since 1929; but the older field of Miri, now on the pump, has been producing since 1911. Exploration is continuing in the hope of finding further fields.

Netherlands New Guinea

Following incidental and scattered investigations by the government Geological Survey and by private companies, oil exploration in New Guinea began on a large scale in 1936. Production so far is limited to the Vogelkop in the westernmost part of New Guinea, where the Klamano field with a production of almost 5000 bbl a day from Miocene limestone has been in operation since 1948. Two further anticlines (Wazian and Mogoi) in the southeast Vogelkop were proved prewar but have not yet been developed. Exploration continues.

Papua

The folded zone of Papua contains numerous seepages of oil and gas and exploration borings have been drilled at various times from 1912 onwards. Intensive exploration started just before the last war and 5 wells have since been drilled—including one at Kariava to 12,621 ft—but with negative results except for minor gas and oil shows. Structural conditions are complex in the folded zone and reservoir rock characteristics are rather unfavorable. Exploration is now proceeding

in an area of more gentle folding with a possibility of porous-reef limestone development; and, although the final results of the project as a whole cannot be judged at present, the outlook does not seem very hopeful.

Australia

Search for oil in Australia has been going on for almost 50 years—with, so far, no real success. There is only one very small field (or perhaps one ought to say one large seepage) at Lakes Entrance, Victoria near the southeast tip of the continent, where the production is of the order of 5 bbl per day of heavy oil with much fresh water and horizontal drilling is in progress from the bottom of a vertical shaft into which this oil drains. Oil shows but no commercial production have been encountered in exploration wells at Roma in southern Queensland. An annual production of about 78,000 bbl is obtained by distillation of oil shale at Glen Davis in New South Wales.

Exploration activity has been widely spread over the continent, and large concessions have been granted in western Australia, central Australia, and Queensland; but in view of the lack of success so far the outlook can hardly be considered promising.

New Zealand

In spite of very considerable testing by the drill, oil production from New Zealand has been negligible (less than 2000 bbl a year recently). Such as there is has come from one small oil field (Moturoa) in the Taranaki area of North Island from which shallow hand-dug oil was produced as long ago as 1866. Recently two better wells have been reported from this field, but the chances of major production appear remote.

Philippines

Although surface oil and gas indications are known and although there are several Tertiary folded bains which might be considered favorable for limited oil accumulation, the chances of major production in the Philippines are negligible.

Japan

Japan has produced oil since the 1870's, but its cumulative production to the end of 1949 was only about 95 million barrels, with a peak of 3 million barrels in 1915 and a production of not much more than one million barrels in 1948. Since then there has been a small increase, which may perhaps continue inasmuch as deeper horizons remain to be tested in several of the producing areas. The oil occurs in central Hokkaido and along the coast of the Sea of Japan in the Akita, Yamagata, and Niigata areas from Pliocene and Miocene formations. The chances of finding commercial oil pools in southwestern Japan are remote.

Present production, which is entirely refined in Japan, meets only about 10 per cent of Japan's consumption of petroleum products and it seems unlikely that this percentage will ever be increased very much.

Korea

The chances of finding oil in Korea are negligible.

China

The only producing oil field in China is at Yumen in Kansu Province, where development has been much retarded by inaccessibility and inadequate equipment, and production is only about 2000 bbl a day. The field does not appear to be individually important in size; but as it occurs in a large folded zone there is good reason to suppose that a number of similar oil fields will eventually be discovered in that region. Elsewhere in China large sedimentary basins with oil and gas indications cover an area of some 300,000 square miles; and, although drilling has been carried out with negative results—in Szechwan Province, for example—there undoubtedly remains more than a possibility that a really intensive search, if and when made, will produce important results. As things are now its seems most unlikely that China will be able to satisfy more than a minute fraction of its total oil requirements for many years to come.

Asiatic Russia

Last we come to the huge area—more than 8 million square miles—of Asiatic Russia.

First there are some small Tertiary fields, both proved and still to be proved, on the eastern border of the Caspian; but although, strictly speaking, these are just in Asiatic Russia, they are so closely linked with the Caucasus fields that I think it better to exclude them from this review.

Next there are the Tertiary fields in the Ferghana region of Turkestan, north of Afghanistan, production from which is believed to be of the order of 7 million barrels a year. Further small fields probably remain to be discovered in this region, perhaps in conjunction with small fields that may be discovered across the border in Afghanistan; but the ratio of oil won to feet drilled is likely to be low and total production is not likely to show any very notable increase.

Tertiary oil fields in Sakhalin are believed to produce some 7 million barrels of oil per year and here again no spectacular developments are probable.

Palaeozoic oil is produced in the Taimyr peninsula in the extreme north of Siberia. Production is almost certainly very small but there have been reports of much activity in this part of the Arctic Circle recently and it may be that intensive efforts to increase production are being made. No big increase is likely to be possible—as production per well and per foot drilled is almost certain to be very small.

So much for those parts of Asiatic Russia where oil has actually been discovered. New discoveries and consequent increases in production are probable in all of these areas (except possibly Sakhalin) but the increases over the next 10 or 20 years are not likely to be either very big or very rapid. Distances are enormous and the effort that has to be put into exploration and development to achieve significant results is very large. However, from a much longer-term point of view—looking ahead 30 or 40 years—the chances of really big oil production in Asiatic Russia are by no means negligible. There appear to be some 3 million square miles of sedimentary cover, much of which must be almost completely unexplored geologically; and it would be surprising, to say the least, if in such an immense region oil were not sooner or later discovered and developed in quantity.

Reserves

The foregoing has shown that there is no certainty as to what the results of future exploration will be. By far the most important and striking fact is that nowhere east of the Urals have we had, so far, the remotest sign of any really prolific oil accumulations of (for want of a better term) Persian Gulf type. The oil fields which have been found and the prospects now in the minds of various companies for testing are all on a relatively very small scale—in many cases on a minute scale in terms of oil to be expected per foot drilled. Such estimates of proved reserves as I have made or collected in connection with this paper do not in general differ sufficiently from de Golyer's estimates to justify separate publication now; and I shall, therefore, merely note that, on de Golyer's most recent figures the Far East as here defined has less than one-fortieth of the world's proved reserves. More than half of the proved reserves of the Far East or in Indonesia, and the next most important countries on present figures are British Borneo (whose proved re-

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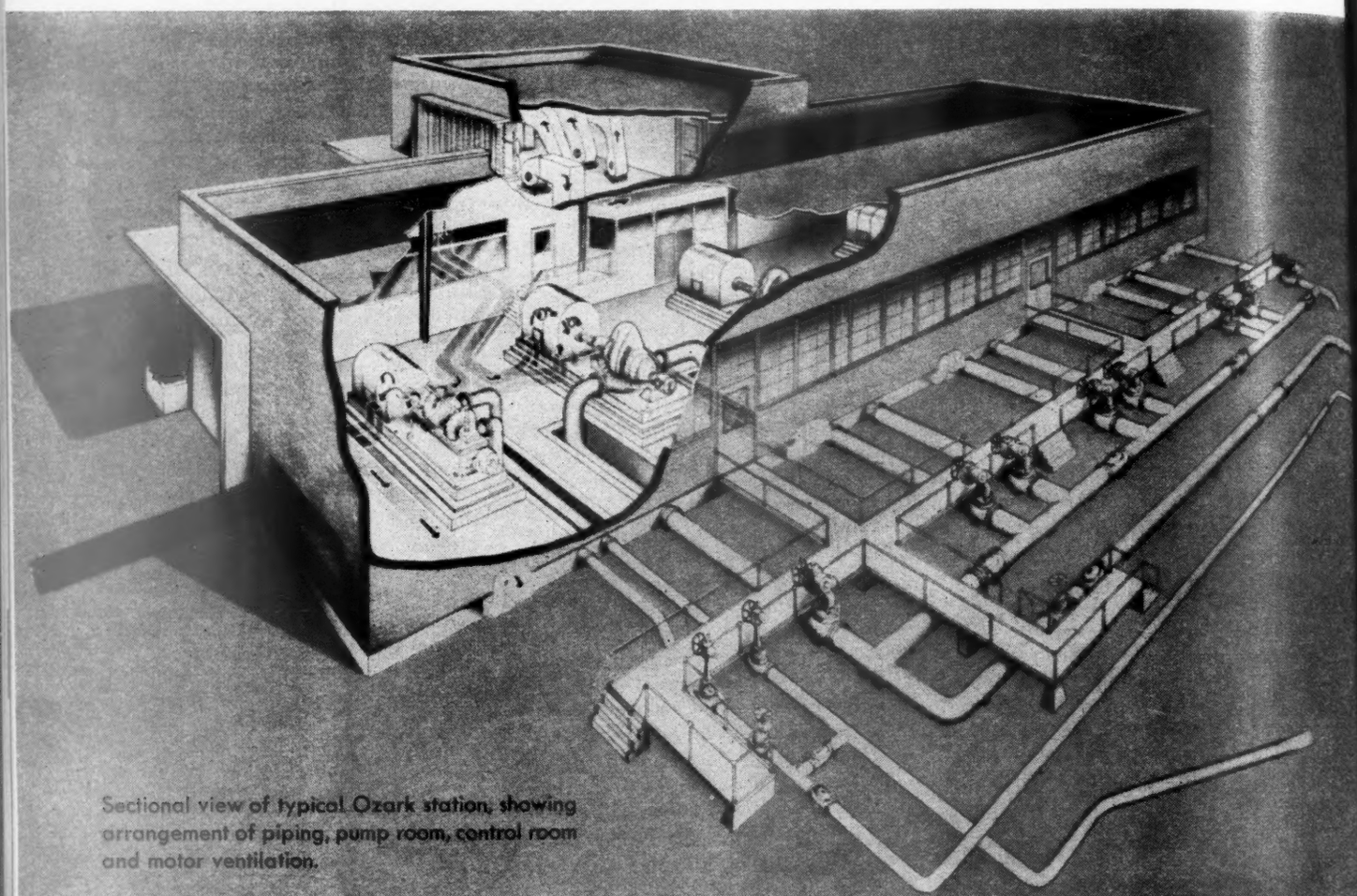
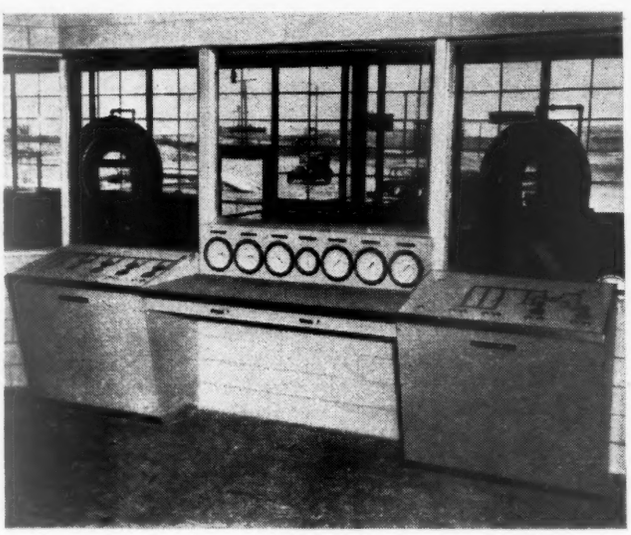


Sectional view of typical Ozark station, showing arrangement of piping, pump room, control room and motor ventilation.



The control desks for the pumping station are located in the operating room overlooking the pump room. Separate desks are provided for the 22-inch line and for the 10-inch lines.

Main pump motor control is Westinghouse 4,160-volt Metal-Clad Switchgear, with air circuit breakers of 100,000-kva interrupting capacity.

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EQUIPMENT FOR THE PETROLEUM INDUSTRY

serves have recently increased appreciably) and Asiatic Russia.

The Future

We now come to the question of whether production in that part of the earth between the Urals-Persian Gulf and the Americas is likely ever to overtake consumption. The answer, in the short run at least, is almost certainly "no." We have seen that consumption even at the present almost unbelievably low rates per head amounts to less than one-twentieth of world consumption; and, if anything is certain, it is that this proportion must increase. I note parenthetically that the distribution of the coal reserves of the world is not such as to invalidate this conclusion. We have seen that proved reserves are only about one-fortieth of the world total; and on broad general grounds and thinking of the next 10 or 20 or 30 years, it is hard to see how such small reserves could cope with the increased consumption, which we must expect. The same conclusion is reached if instead of dealing with the Far East as a whole we consider the main countries of which it is composed. Only a few areas in the East Indian archipelago are likely to have any surpluses over consumption.

How will the deficit be made good? At present the main part of the deficit except for Russia in Asia is made good by oil from the Persian Gulf and a glance at a map of the world, combined with what we know as to America's increasing need for oil, makes it probable that in the main this will continue to be the case. In other words, the phenomenally high concentration of oil per square mile in the Persian Gulf area will be used to compensate for the very much lower concentration throughout the huge area which we have been considering.

It is interesting, in conclusion, to consider separately Asiatic Russia plus China. What has been said previously for the Far East as a whole applies equally to Asiatic Russia plus China insofar as proved reserves are concerned. However, we have seen that both in Asiatic Russia and China there are huge sedimentary basins that have not yet been explored. Exploration and development of such large areas will inevitably be slow; but taking a very long view it is probable that oil reserves considerably greater than suggested by the present rather small "proved" reserves will eventually be found. It is hard to suggest even a tentative figure for these "speculative" reserves but it may well be that an assessment of "proved" reserves in 1990 or 2000 would credit Asiatic Russia plus China with at least 10 per cent of the world's proved reserves, as opposed to (probably) less than ½ per cent today.

A very large part of the additional reserves that I am postulating might be in Russia; and I may perhaps end this short survey with the speculation that in another 20 or 30 years when Russian geologists and technologists have been able to bite deeply in the problem of their vast and hitherto largely unexplored Asian territories, Russia may not have the inferiority complex as regards oil reserves that possibly, and perhaps understandably, she now has in relation to the prolific neighboring areas of the Middle East.

Political Footnote

I have been asked to say something about the political "climate" in the various countries where there are still chances of obtaining appreciable quantities of new oil especially from the point of view of American investors. I shall not say anything in this connection about Asiatic Russia and China; and of the remaining countries the only ones to which I need refer—under the two quite separate headings of (a) mining rules, etc., and (b) political stability—are Australia, Papua, Indonesia, Borneo, Burma, India, and Pakistan.

Australia, politically stable, offers great security to operators and the Australian government has done much to encourage oil exploration. The same applies to Papua but that country is still in a very undeveloped state and there are some stringent regulations to protect the indigenous population. British Borneo consists of three separate political units but all are stable and exploration conditions are reasonable.

The present government of Indonesia as a single unit (as opposed to a federal system) was formed only last September and it is too early to say what its policy will be as regards development of its oil resources.

Burma has been passing through a period of great political unrest; and although the government has recently re-asserted its control in a number of areas the country as a whole is not yet safe for normal business. The Burmese government's ultimate objective is nationalization of the mineral production but when and in what degree this will eventually be enforced is not yet known.

India and Pakistan both have stable administrations and the greatest threat to security here lies in deep-seated tension—largely religious in origin—between the two countries. The unsettled issue of Kashmir does much to keep this antagonism alive. Both in India and in Pakistan the mining rules are on the whole reasonable and there is no differentiation of any kind as between American and British capital.

All of these countries are of course very "oil-conscious" and anxious both for commercial and strategic reasons to have their own indigenous oil supplies. Not all of them have yet fully appreciated the worldwide significance of the great and rapidly growing Middle East production or that self-sufficiency in oil must everywhere be the exception rather than the rule. The truth is, of course, that international movement of oil as of many other commodities will remain essential to world progress; and there can be few more striking examples of the interdependence of different parts of the globe or of the benefits that, *given real peace*, world trade can confer, than the fact that one-half of the human race has such a very small fraction of the world's oil.

Acknowledgment

I am grateful to the Shell, Anglo-Iranian, Standard-Vacuum, and Caltex oil companies for help in the preparation of this paper.

* * *

Brigadier Means Oil Operator in Romania

Communists in Romania are having difficulty keeping their oil business running. Their best scientists are doing the office work, while their unskilled workers are deciding where oil wells should be drilled. Their machinery is being sabotaged, although the Romanian oil bosses prefer to call it "machinery breakdowns." In a scathing directive to its oil industry, the Romanian government reported that Romania had failed to meet its goals of oil production or drilling since the properties were seized from Anglo-American interests. The directive was broadcast over the Bucharest radio and heard by American moniters. It is the exact opposite of the official report that nationalization has increased production 140 per cent.

As an incentive to oil workers, and in an attempt to overcome these problems, the government ordered bonuses to workers and more clothing ration cards. It has given them new titles, hereafter calling the man in charge of a well a brigadier and the man directing a particularly tough job a chief brigadier.

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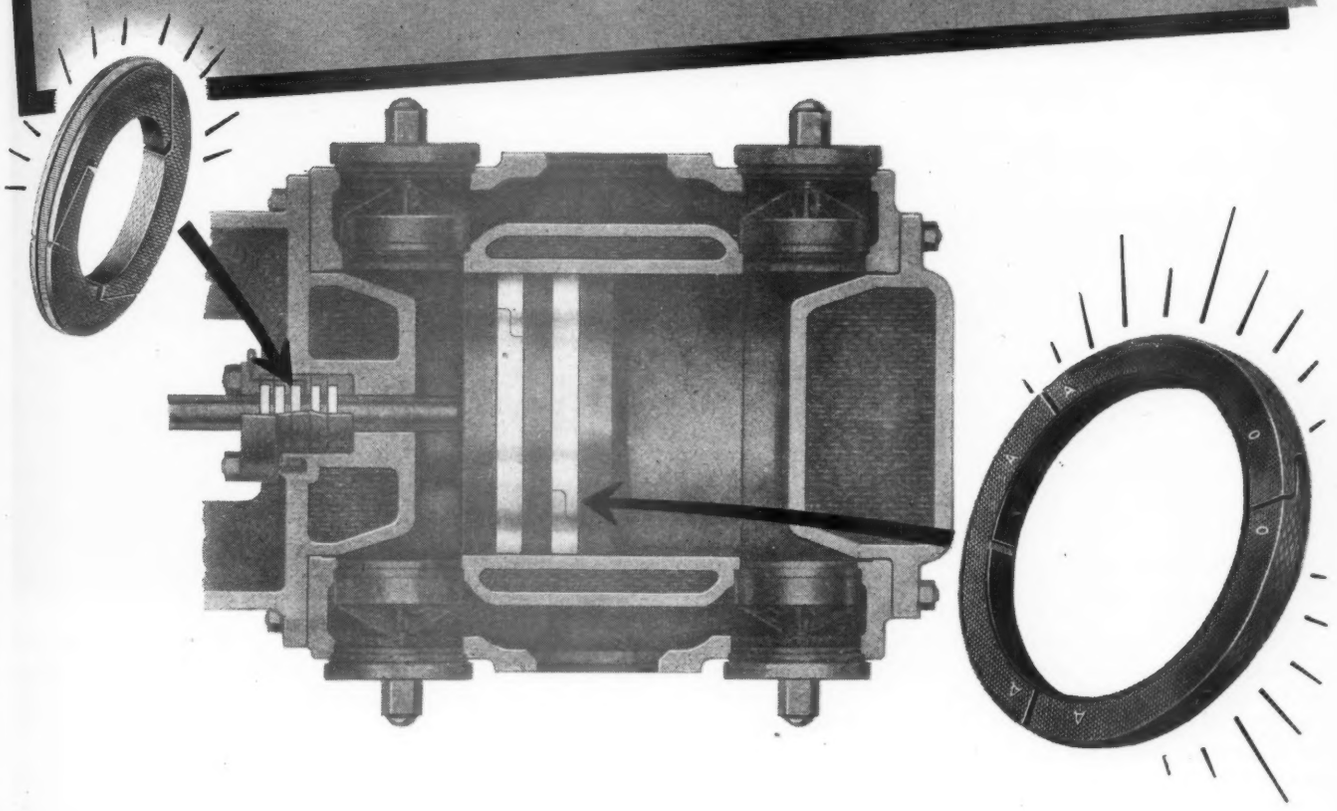

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PETROLEUM PROFILE

O. Q. Lomax
President
Humble Pipe
Line Company

A native midwesterner who's lived in Texas most of his life, thanks to the oil industry, is O. Q. Lomax, new president of Humble Pipe Line Company. Lomax's election as president was announced October 10, 1950.

Lomax was born in Paoli, Indiana, in 1893 and later lived in Kansas. He attended the University of Kansas in Lawrence, worked for Empire Gas and Fuel Company in Bartlesville, Oklahoma, and served for a short time in the army before going to work for Humble Oil and Refining Company in December, 1918.

One of his first jobs was assisting with preliminary field survey and planning for Humble's Baytown refinery. Baytown, with its giant plants and docks of today, was little more than swampy rice land and dogwood groves three decades ago. In the spring of 1919, Lomax transferred to Humble Pipe Line Company as an engineer-draftsman.

Here he worked on the design and construction plans of Humble's first major pipe line project, an 8-in. line from the booming Ranger area to Texas City, with a lateral from West Columbia to Webster and from Webster to Texas City. R. V. Hanrahan, whom he succeeded as Humble Pipe Line president, was then general superintendent.

Lomax worked for other oil firms and construction contractors between 1919 and 1924, when he returned to Humble Pipe Line Company. In March, 1922, he married Hellen Parker, a Texas girl whom he met while in Port Arthur with The Texas Company.

Since coming back to Humble in 1924, Lomax has had offices in Houston. However, when World War II came along, he went to Washington, D. C., many times to help with wartime transportation problems, particularly those in connection with the construction and operation of Southwest Emergency Pipe Line Company, a government-owned project.

In the years between 1924 and 1937, he served at different times as engineer - draftsman, design draftsman, chief draftsman, assistant chief engineer, and acting chief engineer.

Lomax was appointed Southern Division superintendent in 1937. Six months later he became assistant general superintendent and served in this position until 1942, when he was elected to the Humble Pipe Line Company's board of directors and made vice president and general superintendent.

The Lomaxes have just moved into a new, air-conditioned, modern bungalow. They have a daughter, Joanne, 20, who has been attending Stephens College and is planning to enter the University of Houston in the spring term.

Lomax admits to all of the average business man's spare-time "vices"—golf, hunting, fishing, card playing, and other hobbies. He is president of Brae-Burn Country Club and a past vice president and director of the Houston Engineers Club. He is a member of the Houston Chamber of Commerce, the South Texas Chamber of Commerce, the Texas Mid-Continent Oil and Gas Association, and the National Association of Corrosion Engineers.

He says there are lots of other things he'd like to do, but there's not enough time after work. In fact, "It seems to me that about all a man has time to attend to is his business," he says.

Waterflooding Is Still In Its Infancy!

PEOPLE who have heard and read of the application of the waterflooding technique to the old shallow fields in the Eastern part of the U.S. might be surprised by the results of recent field by field and county by county surveys of the extent of present waterflooding practice. On January 1, 1950, for example, there were only 31 active "controlled" floods in the State of Illinois covering only about 8,450 of the 376,000 acres of oil-producing area in the State.

Here, then, is a state where less than 3 per cent of the total oil-producing area is being "control" flooded. The area being flooded by natural water drives and/or "dump" floods is certainly not more than 7 per cent of the total area, so at least 90 per cent of the oil field area of Illinois remains to be flooded.

A recent survey in the State of Pennsylvania indicates that waterflooding projects have been tried in only 31 of the State's 164 oil fields. Flooding was successful in about 14 of these fields and, for one reason or another, it was unsuccessful in about 17 fields. Flooding is not being applied, however, to all the area of these 14 fields. In Bradford (Pennsylvania portion), for example, it is estimated that 63,000,000 bbl of oil may be recovered by intensive waterflooding of "undeveloped" areas that should yield 2500 or more bbl per acre, and that 9,000,000 bbl may be recovered in areas that should yield 1500 bbl per acre.

Although a considerable part of the 72,450 oil-producing acres in the Pennsylvania portion of Bradford have been flooded out by some of the intensive floods that began about 1928, and the field has produced about 400,000,000 bbl (or, more than twice as much as it would have produced by this time naturally), . . . there are about 30,000 acres in this one field that should yield about 72,000,000 bbl more by intensive waterflooding.

All the area of old shallow fields is probably not worth waterflooding at the present price of crude oil and the present cost of development; however, intensive waterflooding practice will be extended so long as the economic outlook remains favorable. Waterflood operators need not only a favorable outlook for the price of oil but also properties that indicate a substantial profit from the planned investment in waterflood facilities.

Operators who have risked their money and efforts on past and present waterflooding projects have made a great contribution to the art of secondary recovery. They are lighting the way for others who want to make money by flooding some of the great areas that remain. Waterflooding is still in its infancy!—KMF

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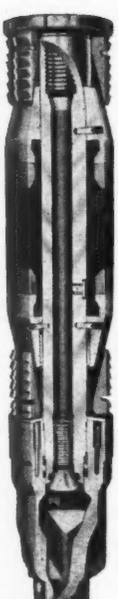

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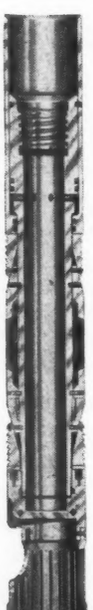

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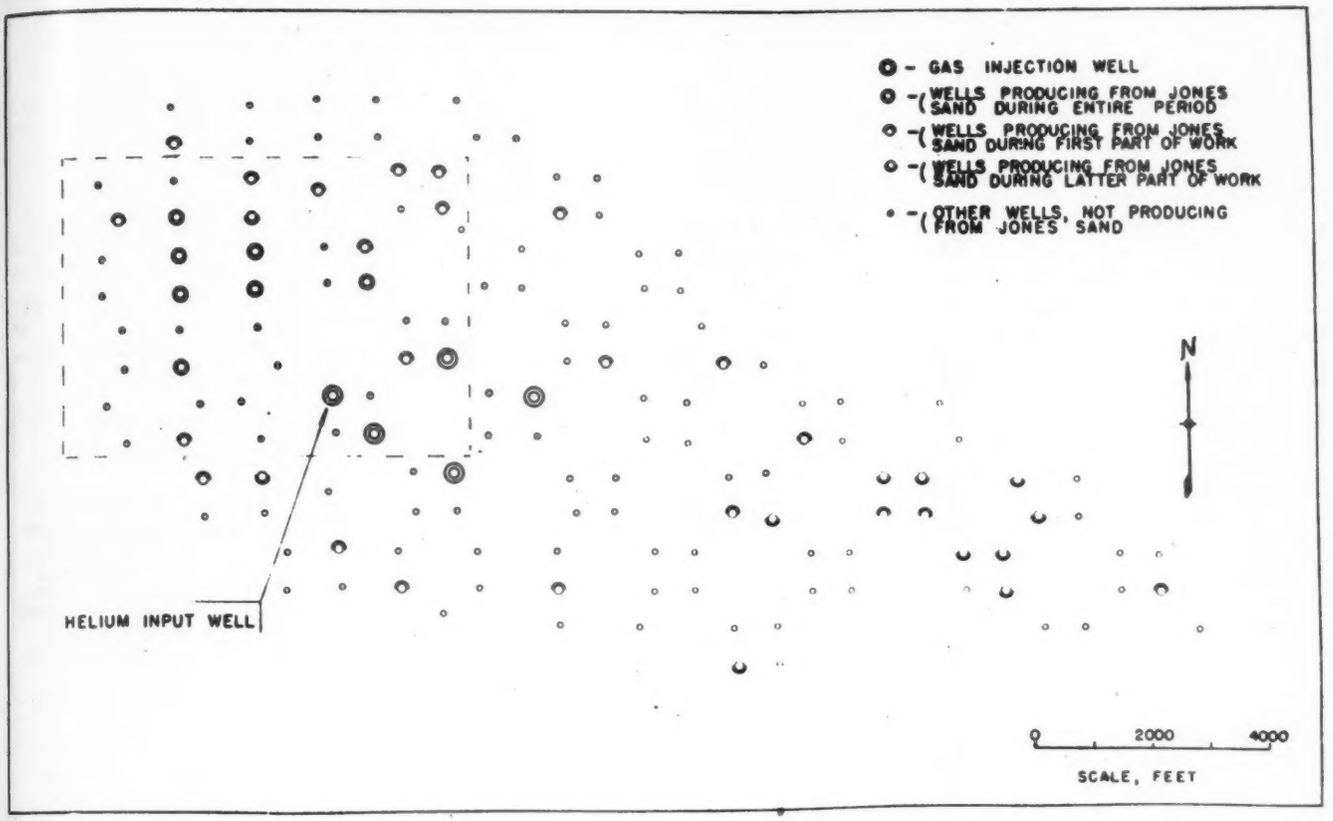
GAS INJECTION WELL
WELLS PRODUCING FROM JONES SAND DURING ENTIRE PERIOD
WELLS PRODUCING FROM JONES SAND DURING FIRST PART OF WORK
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OTHER WELLS, NOT PRODUCING FROM JONES SAND
N
HELIUM INPUT WELL
0
2000
4000
SCALE, FEET

FIG. 1. Surface map of Shuler, Arkansas, field. Boundary of map in Fig. 2 is shown by dotted lines.

Shuler Field, Arkansas

Helium Tracer Gas Studies*

E. M. FROST, JR.†

Abstract

A COOPERATIVE helium tracer gas project was conducted in the Jones sand section of the Shuler oil and gas field, Union County, Arkansas, by the Bureau of Mines and the Lion Oil Company, operators for the Shuler Unit. The Bureau has pioneered the use of helium as a tracer gas, and has published its findings in cooperative helium tracer gas projects in the Elk Hills, California, and Cabin Creek, West Virginia, oil and gas fields. Officials of the Lion Oil Company, after reviewing these published data, decided upon a helium tracer gas project in the Shuler field to furnish information needed for a better understanding of operating problems. The Bureau desired additional data to extend its experience with this new use for helium, and entered into a cooperative agreement with the Lion Oil Company to assist in the Shuler project in return for the privilege of publishing the data relating to the use of helium as a tracer.

A natural-gas injection program has been in operation in the Shuler field for several years, and there was no interruption in this established injection program during the period covered by the helium tracer gas project. Gas was being injected at 5 separate wells situated on top of the structure. Arrangements were made to add tracer helium exclusively to the gas being injected at one of these wells, and during a 5-day period the helium was added in quantity sufficient to raise the helium content of the gas from a normal of 0.022 per cent to approximately 1 per cent, or an approximate 45-fold increase. The gas that was being injected was collected from separators over the field, and the 0.022 per cent helium was the composite of the gas being produced in the field. The gas produced from various individual wells was found to contain helium in concentrations ranging from about 0.019 per cent to 0.024 per cent. The tracer helium that was added to the natural gas was detected in gas produced at various wells during the succeeding 1½ years. The total volume of tracer helium appearing in the produced gases during the 1½ years amounted to more than 95 per cent of the original volume of tracer helium that was added to the injected gas. *(Article begins on next page.)*

*Work on manuscript completed in 1950.
†Chemical Engineer, Petroleum and Natural Gas Branch, U.S.B.M., Amarillo, Texas.

EXCLUSIVE

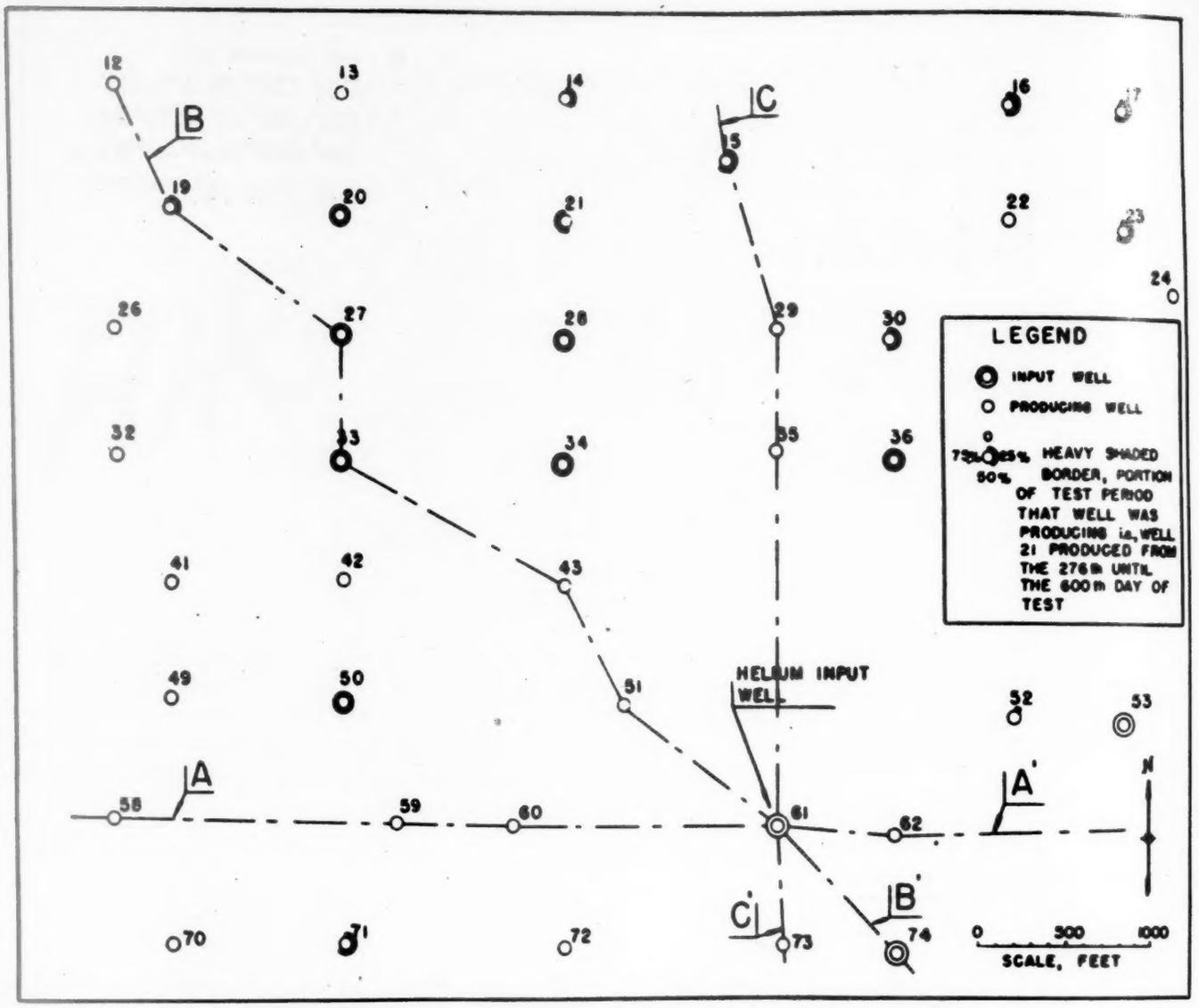

FIG. 2. Surface map showing on a more open scale the Shuler field in the vicinity of the helium input well, including all wells at which tracer helium appeared.

THE use of helium as a tracer gas in oil and gas field operations was introduced by the Bureau of Mines, and previous articles have been published[3, 4, 5] describing the usual mechanics of the projects and the results obtained.

Officials of the Lion Oil Company, after reviewing some of these reports, arranged to conduct a helium tracer gas project in the Jones sand of the Shuler field to obtain information related to production operations. The Bureau of Mines desired additional data to extend its experience in the use of helium as a tracer gas, and entered into a cooperative agreement with the Lion Oil Company to assist in the Shuler project in return for the privilege of publishing the data relating to the use of helium as a tracer gas. The successful application of the helium tracer gas technique and the collection of the subsequent data were the objective of the Bureau, and it has not concerned itself with the application of these data in field production operations as this application is outside the scope of this publication.

A volume of 141,000 cu ft of tracer helium was added to the injected gas. A total volume of 129,000 cu ft of tracer helium, or 91.4 per cent of the total that was injected, was detected in the produced gas. Further, the operation at some of the wells was interrupted to prevent obtaining further data while the wells still were producing small volumes of tracer helium, and an extrapolation of the data at these wells indicated that an additional volume of 7400 cu ft, or an additional 5.2 per cent would have been produced. Thus, a total of approximately 96.6 per cent of the tracer helium that was added at the injection well was detected in the gases produced from the surrounding wells.

3. Frost, E. M., Jr. Helium Tracer Studies in the Elk Hills, California, Field; Bureau of Mines R. I. 3897, 1946, 6 pp.
4. Frost, E. M., Jr. Use of Helium as a Tracer in Oil and Gas Fields; Petroleum Engineer Reference Annual, Vol. 18, No. 10 (1947), pp. 140-52.
5. Frost, E. M., Jr. Helium Tracer Gas Studies in the Cabin Creek, West Virginia, Oil and Gas Field; Bureau of Mines R. I., 4715, 1950, 62 pp.

Acknowledgments

The author gratefully acknowledges the helpful assistance of Lion Oil Company personnel, including J. E. Howell, vice president in charge of production and pipe lines, F. E. Steele, general production superintendent, Frank Richardson, assistant to Howell, T. F. Davis, superintendent of the Shuler Unit, John Catlin, chief production engineer, A. G. Burki, senior petroleum engineer, Shuler Unit, and others in the collection and furnishing of data and in the editorial review of this manuscript.

Appreciation also is expressed to

E. M. Tignor, A. B. Cook, G. B. Shea, R. V. Higgins, and others of the Bureau of Mines staff, for review and criticism of the manuscript.

Description of Field

The Shuler, Arkansas, field has been described in the literature[6, 7]. A surface map showing the well locations, is given in Fig. 1. The field in the vicinity of the tracer-laden gas injection well is shown on a larger scale in Fig. 2. Cross sections of the Jones sand along traverses A-A′, B-B′, C-C′, of Fig. 2 are shown in Figs. 3, 4, and 5, respectively. Cores were taken by use of rotary drilling equipment through part or all of the Jones sand oil- and gas-producing zones in several of the wells in the vicinity of the selected injection well, and the permeability and porosity profiles of these cores are shown in Figs. 6 and 7. The permeability of the cores was found to vary from virtually zero to a maximum of slightly above 3500 millidarcys, and the porosity was found to vary from 0 to about 22 per cent. Lion Oil officials reported that more recent tests, however, indicate that maximum permeabilities may be as high as 7300 millidarcys.

The first injection of natural gas into the structure was started during the summer of 1941 as a pressure-maintenance project, and has continued without interruption since that time. The gas is injected through 5 wells near the top of the structure as shown on Fig. 1. During the first 2½ years of gas injection, the average total rate of injection into the formation through all wells was about 22,000,000 cu ft per day, and during the succeeding time through that covered by the present report, the average rate was about 27,000,000 cu ft per day.

Well No. 61, Fig. 2, was selected by the operators for injecting the tracer helium into the formation. Natural gas was being injected at this well at a rate of approximately 3,000,000 cu ft per day at wellhead pressure of 1270 psia. Gas was injected at the 4 additional injection wells, shown on Fig. 1, at rates ranging from 3½ million to nearly 8,000,000 cu ft per day. The gas that was injected was that produced from the Jones sand in connection with the production of oil and was processed in a natural gasoline plant before reinjection. In the normal injection operations, the gas from the gasoline plant was compressed into a common header from which it was distributed in controlled proportions to the various injection wells. This gas was found to contain 0.022 per cent helium by volume and the project was planned on the basis of increasing this to approximately 1 per cent for a 5-day period.

Helium was shipped to the field in containers at a pressure of approximately 2000 psi. The prevailing pressure of 1270 lb at the injection well would prevent an efficient transfer of this helium from the shipping containers direct into the injection gas pipe line by throttling. The compressor suction line pressure was sufficiently low, however, to permit transferring the helium into it efficiently by throttling, and this was done. The compressor station piping provided connections to throttle the helium into the gas going exclusively to any individual compressor. The discharge line of one compressor was disconnected from the header and was connected to a temporary line laid on the surface and connecting to the line carrying gas exclusively to well No. 61. The concentration of tracer helium in the gas going to well No. 61 was controlled by throttling the helium into the suction line of this particular compressor at the proper rate. This rate at which the helium was added to the injection gas was regulated manually by noting the differential across an orifice in the manifold that was used to transfer helium from the shipping containers into the pipe line. The concentration of helium in the injection gas was confirmed by taking repeated samples at the wellhead and analyzing them for helium content. Helium was added to the gas continuously from 2:00 p. m. of the starting day until 2:45 p. m. of the fifth day following, and during this approximate 5-day period the weighted average helium content of the injected gas was 1.018 per cent

6. Kaveler, H. H., Engineering Features of the Shuler Field and Unit Operation; AIME Technical Bulletin No. 1605, 1943, 28 pp.
7. Shreveport Geological Society, 1945 Reference Report on Certain Oil and Gas Fields of North Louisiana, South Arkansas, Mississippi, and Alabama, Vol. 1, pp. 67-74.

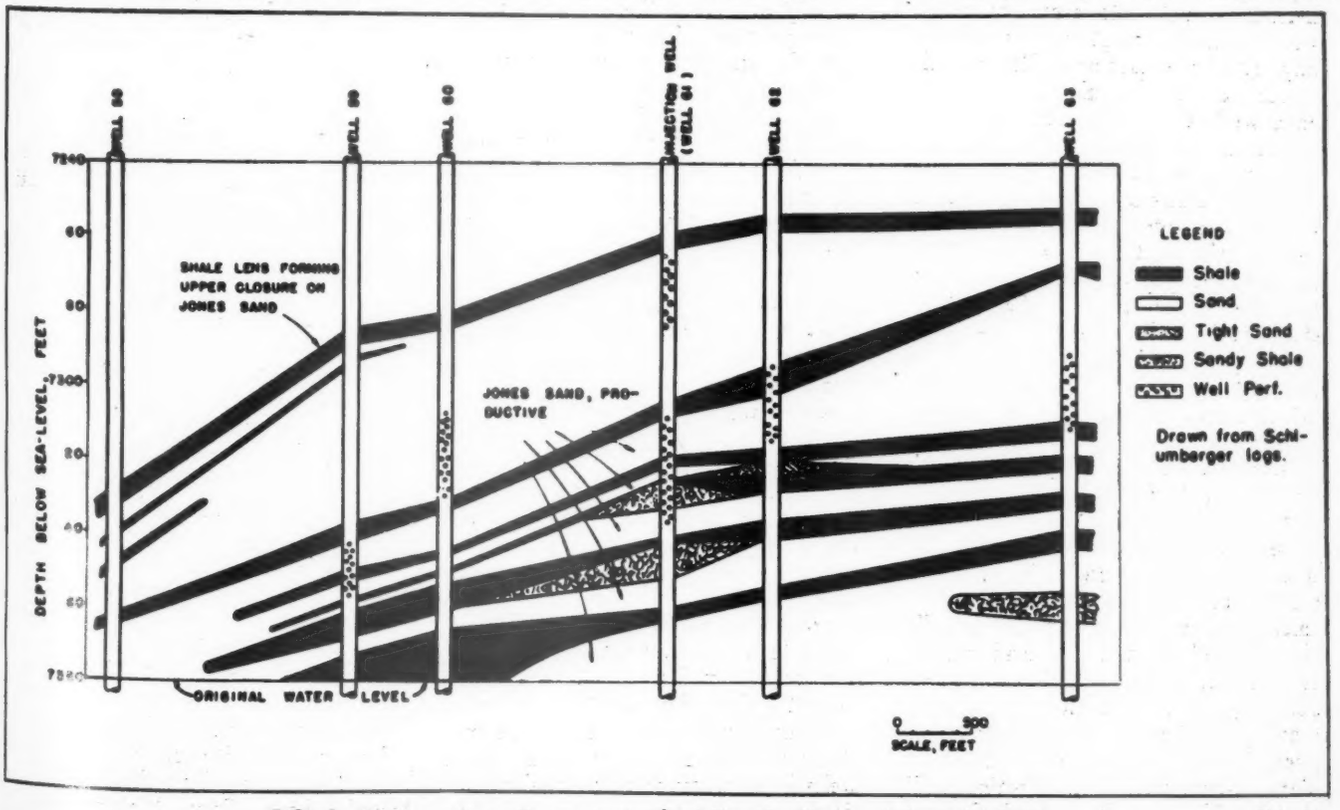

FIG. 3. Section along Traverse A-A′ of Fig. 2, Shuler, Arkansas, field.

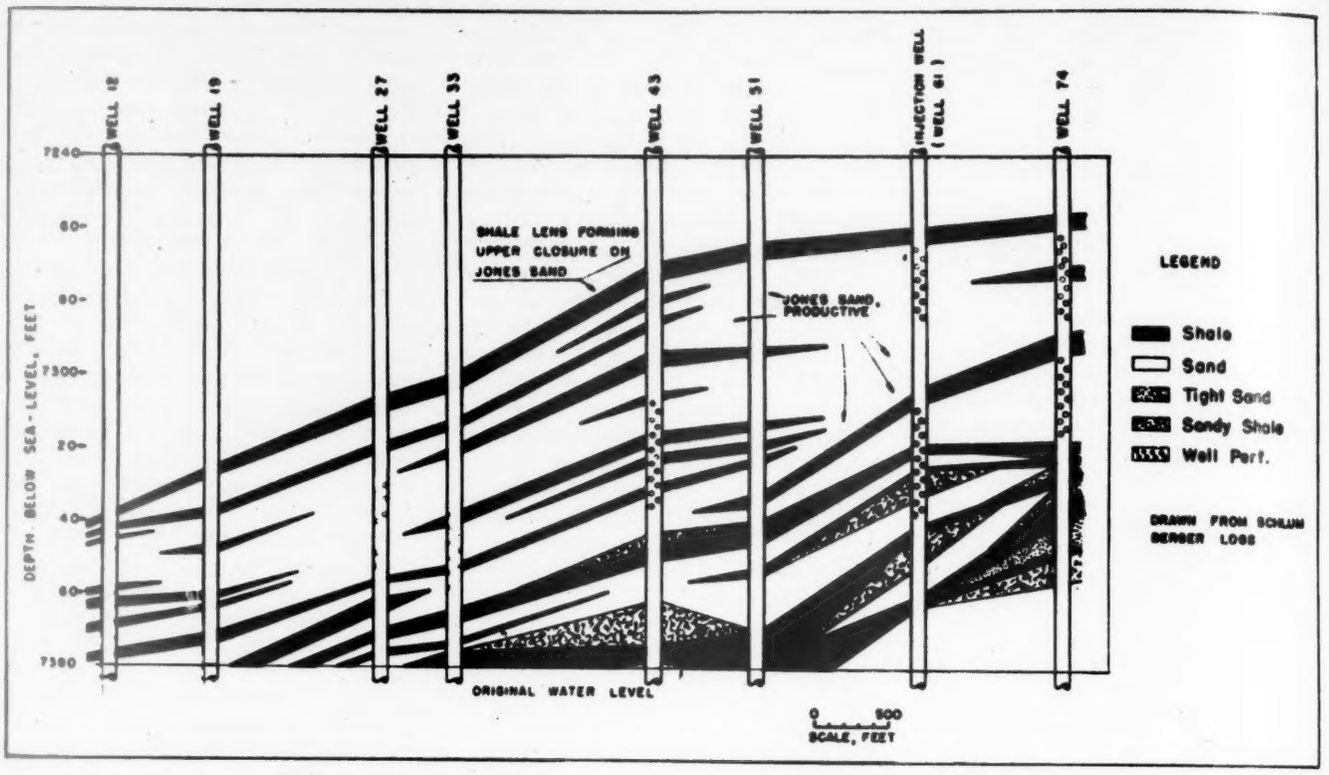

FIG. 4. Section along Traverse B-B′ of Fig. 2, Shuler, Arkansas, field.

by volume. Injection of natural gas, containing the normal concentration of 0.022 per cent helium, continued without interruption after completing the addition of tracer gas.

Samples of produced gases were obtained at regular intervals and analyzed for helium content, and the helium-content data from each well were plotted against time in elapsed days from the start of addition of the tracer gas. The resulting graphs for each well at which the tracer helium appeared are shown in Fig. 8. These wells are (Fig. 2) Nos. 20, 27, 28, 33, 34, and 50. The sustained increases in helium contents shown in Fig. 8 reveal clearly the time of arrival of the tracer-laden gas at each of the wells and the length of time that it persisted at the wells.

The graphs of Fig. 8 reveal several unusual facts about the flow of the injected gas through the formation. The tracer helium appeared in greatest concentration in the gas from well No. 27, which is farther from the injection well than any of the other tracer-producing wells except No. 20. It appeared in somewhat less concentration at well No. 34, appeared in smaller amounts about equally at wells Nos. 20 and 33, and appeared in least concentrations at wells Nos. 28 and 50. Thus, it appears that the gas in moving out through the formation followed a very narrow path centering along a line from the injection well to well No. 27. It arrived first at well No. 34, after an elapsed time of 115 days, and arrived last at well No. 50 after an elapsed time of 389 days. The wave persisted at some of the wells for a year or more, compared to the 5-day period during which it was injected into the formation.

In the collection of the data plotted in Fig. 8, during the period prior to the confirmed presence of the tracer gas, the analyst sometimes would report helium contents materially higher than the established value. In these instances duplicate samples often would be collected as promptly as practical for confirmation analysis, and if the duplicates did not confirm the presence of tracer helium, the occasional high values were ignored. The graphs of Fig. 8 were drawn to show the average initial values of helium contents, and to show the reported helium contents for those periods during which sustained increases in the helium contents prevailed.

Tracer helium still was being produced at some wells near the end of the project, though in relatively small and progressively decreasing amounts when they either were shut in or were converted to a gas-lift system of production, and no further data could be collected. In these instances, the graphs of Fig. 8 were extrapolated to permit calculation of the estimated additional volumes of tracer helium that would have been produced if the wells had remained in normal operation.

Volumetric Calculations of Helium

The volume of tracer helium that was produced at each of the wells was calculated from the helium content data shown graphically in Fig. 8. The calculation was made by obtaining from Fig. 8 the average increase in per cent of helium and from production records the total volume of gas produced at each well and multiplying the total volume by the increase in per cent of helium. The average increase in the per cent of helium was obtained by measuring with a planimeter the area within that portion of each graph of Fig. 8 bounded on the lower side by the projected normal helium content of the gas and on the upper side by the graph of helium content data. This area then was divided by the length corresponding to the number of days during which tracer helium was produced to obtain the average height of the area and in so doing to provide the average increase in helium content of the gas. In the normal production operations in the field, flow from each well was controlled by a fixed choke, and as long as a given choke was installed at a well, the day-to-day rate of production as revealed by recording orifice meters was virtually constant. Occasionally the chokes would be changed to meet changing conditions, and the corresponding rate of production of gas would change. Separate measurements

were made on the graphs of Fig. 8 to determine the average increase in helium content for each period during which a specific flow rate of gas prevailed.

The total volumes of produced tracer gas thus calculated are shown in Table 1, wherein Column 2 shows the volume of tracer helium produced at each well and Column 3 shows the estimated additional production as obtained from extrapolation of the graphs of Fig. 8. The sum of the calculated production and the estimated additional production for each well is shown in Column 4. Calculation then was made of the percentages that the volume of tracer helium produced at each well bear to the sum of the total volume of tracer helium that was produced and the estimated additional production (the total volume of Column 4) and to the total volume of tracer helium that was injected into the formation (141,173 cu ft at 14.65 and 60 deg). These percentages are listed in Columns 5 and 6, respectively, of Table 1. Thus, 96.6 per cent of the initially injected tracer helium is accounted for, the known volume produced amounting to 91.3 per cent and the estimated additional production, mixed with the Nixon lift gas or lost due to shutting in wells, amounting to an additional 5.3 per cent.

TABLE 1. Distribution of tracer helium, Shuler, Arkansas, field.

Well No.	Total volume of tracer helium produced, cubic feet	Estimated additional volumes of tracer helium, cubic feet	Sum of columns 2 and 3, cubic feet	Ratio of individual volumes of column 4 to total of that column, per cent[1]	Ratio of individual volumes of column 4 to total volume of tracer heliuro injected, per cent[2]
1	2	3	4	5	6
20	10,600	1,200	11,800	8.7	8.3
27	43,600	0	43,600	31.9	30.9
28	5,400	0	5,400	4.0	3.8
33	14,500	700	15,200	11.1	10.8
34	50,300	5,500	55,800	40.9	39.5
50	4,600	0	4,600	3.4	3.3
	129,000	7,400	136,400	100.0	96.6[3]

[1] The total volumes of tracer helium arriving at each of the wells was summarized in column 4.

[2] Calculation was then made of the percentage that these volumes bear to the total tracer helium produced at all wells, and to the total volume that was injected into the formation. The first ratio is shown in column 5 and the latter ratio shown in column 6.

[3] Of this amount, 91.4 per cent was produced and 5.2 per cent was the estimated additional production based on extrapolation of graphs of helium-content data, in those instances where wells were shut in or were converted to the Nixon gas-lift while tracer helium still was present in the gas.

Calculation of Injected Gas in Produced Gas

The percentage of injected gas in the produced gas at the various wells may be calculated from the helium-content data, according to the following analysis.

The field operating records indicate that, under the constant reservoir pressure existing in the field, there was no essential net change in the total quantity of gas in the gas cap during the period covered by the tests,[a] so that, as each volume of tracer-laden injected gas entered the formation, it literally pushed a column of gas ahead of it through the formation and caused to be delivered into the well bore and produced a volume equal to that entering at the injected well. The tracer-laden gas in the present instance was injected for an approximate five-day period and during these five days was entering the flow channels to the various producing wells and causing an equal volume of gas to be displaced out of the channels and be produced. Thus,

[a] Oil was being produced from the reservoir, but a water table was rising under the oil remaining in the reservoir to fill at least a major portion of the space voided by the production of the oil, and it appeared reasonable to assume that the gas-oil interface did not change any material amount during the course of the helium tracer-gas tests.

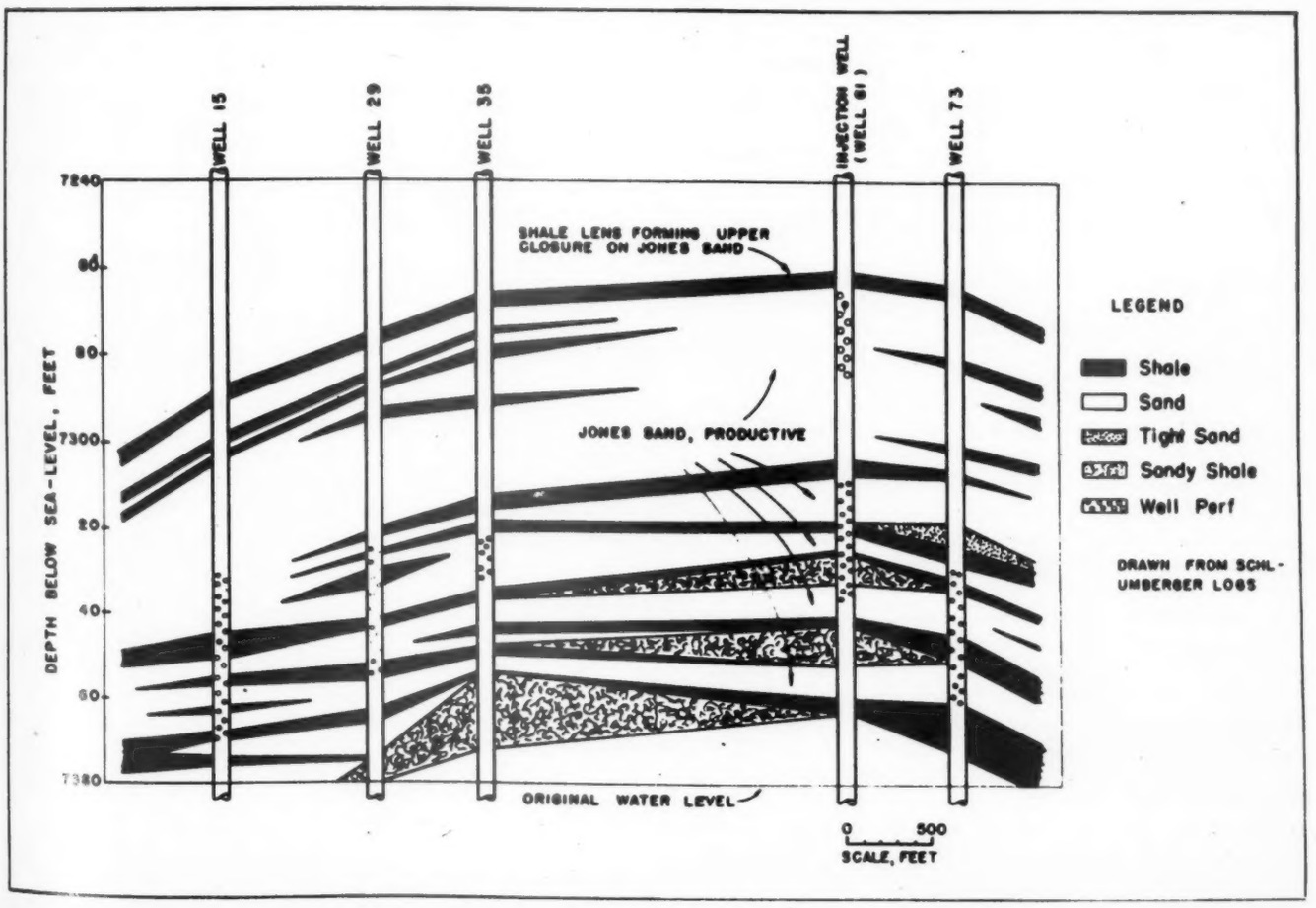

FIG. 5. Section along Traverse C-C' of Fig 2, Shuler, Arkansas, field.

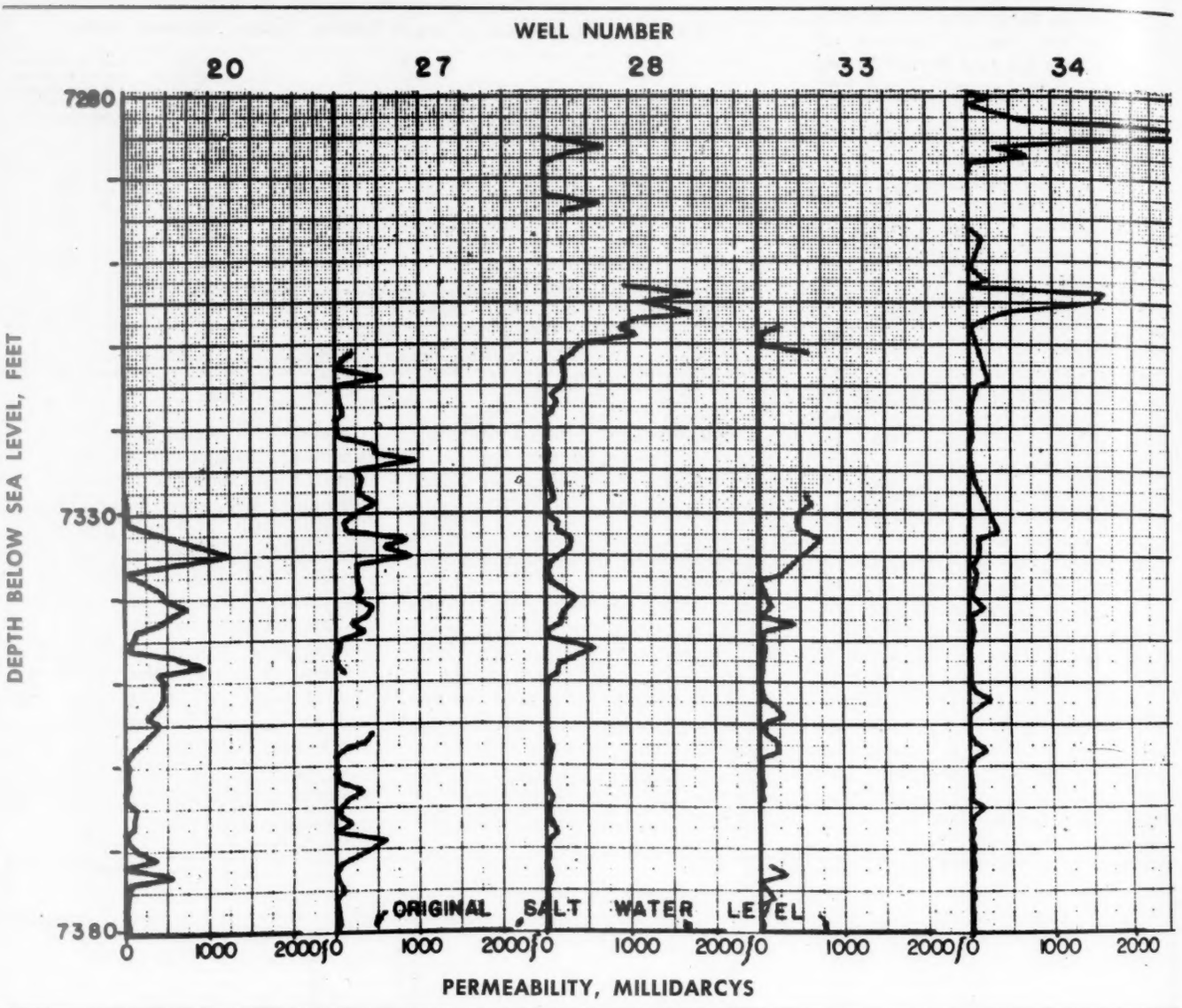

FIG. 6. Permeability profiles of all except one well at which tracer helium appeared.

the volume of tracer-laden gas entering the flow channels to a specific well during this period will equal the volume of gas produced from them. The volume of tracer-laden gas that enters the flow channels to a given producing well can be determined when it reaches the producing well and is produced. The injected gas entered the formation during a five-day period but its arrival at the producing well was distributed over many days, owing apparently to extensive fingering out in the formation.

Tracer helium arriving eventually at a producing well may be determined as outlined earlier in this report, and this volume when eventually determined will reveal the volume of gas entering and the volume of gas produced from the flow channels into the producing well during a 5-day period. The total volume of tracer helium that was produced or estimated to be produced at each of the wells was listed in column 4 of Table 1 and is repeated in column 2 of Table 2. These are the volumes that entered the flow channels to the respective wells during a 5.03-day period. The volume entering per day was obtained by dividing the total volume (column 2, Table 2) by 5.03, and is listed in column 3 of Table 2. As these volumes of tracer helium comprised only 1.018 per cent of the tracer-laden injected gas, the total volume of tracer-laden gas entering each of the flow channels per day may be calculated by dividing the volumes of tracer gas by .01018, and the volumes thus calculated are listed in column 4 of Table 2. These are the calculated volumes of gas reaching the producing wells through the flow channels from the injection well each day.

The average total daily rate of production of gas from the wells was obtained from field operating records, and is listed in column 5 of Table 2. The percentage of the produced gas that reaches the producing well through the flow channels from the injection well is the ratio of the volumes of column 4 to the corresponding volumes of column 5, Table 2, and these percentages are listed in column 6. They reveal that the proportion of the produced gases reaching the wells through the flow channels from injection well No. 61 varies from a minimum of 5.1 per cent at well No. 50 to a maximum of 83.1 per cent at well No. 27. Well No. 27 is farther from the injection well than any of the others, except well No. 20, that received tracer-laden gas from the injection well.

Transition Phenomena

The transition from natural gas to injected gas or to a mixture of nat-

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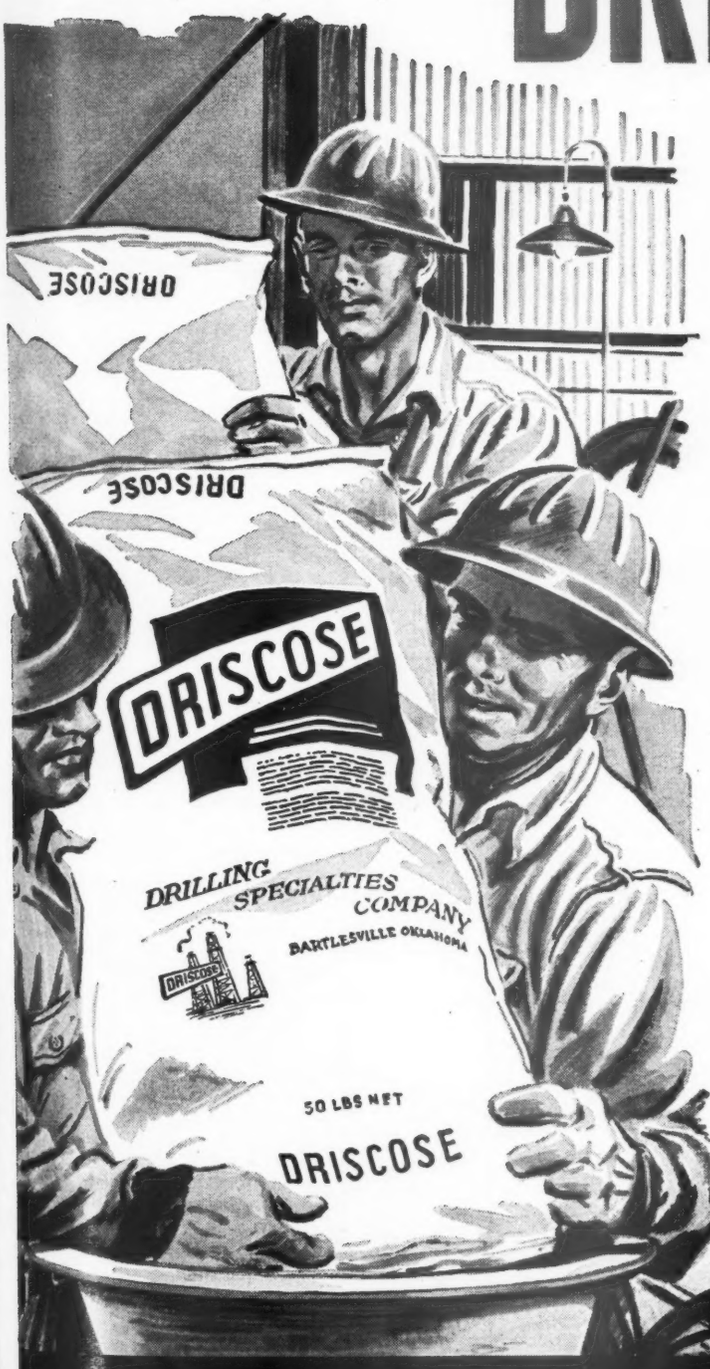

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TABLE 2. Distribution of tracer-laden gas, Shuler, Arkansas, field.

Well No.	Total volume of tracer helium that was produced, cubic feet[1]	Volume of tracer helium per day, cubic feet[2]	Equivalent volume of tracer-laden gas per day, cubic feet[3]	Total daily production of gas from well, cubic feet	Injected gas in produced gas, per cent[4]
1	2	3	4	5	6
20	11,800	2,346	230,400	612,000	37.6
27	43,600	8,668	851,500	1,024,900	83.1
28	5,400	1,074	105,500	768,600	13.7
33	15,200	3,022	296,900	570,900	52.0
34	55,800	11,093	1,089,700	1,485,600	73.3
50	4,600	915	89,900	1,756,600	.5.1

[1] A repetition of the data comprising column 4 of table 2.

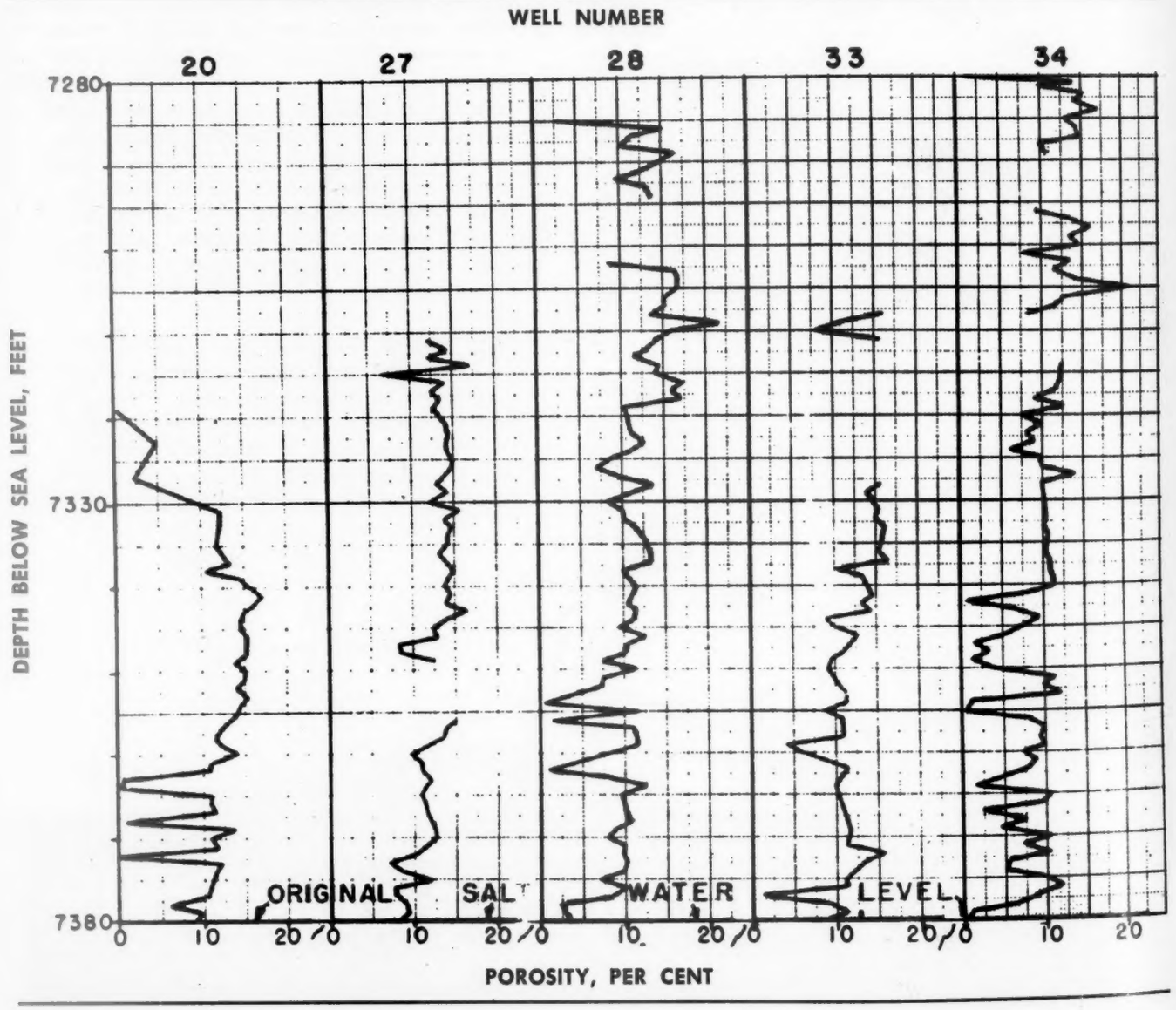
[2] Obtained by dividing the volumes of column 2 by 5.03, the number of days during which tracer helium was added to the injected gas.

[3] As the volumes of column 3 comprise only 0.01018 of the volume of tracer-laden gas, (the tracer-laden gas contained an average of 1.018 per cent helium by volume) the volumes in column 4 were obtained by dividing those of column 3 by 0.01018.

[4] (col. 3/col. 4) x 100

ural and injected gas at the producing wells may be presented graphically by use of the helium tracer gas data, and the results obtained may be used to calculate by another method the concentration of injected gas in the produced gases. The graph may be constructed progressively as the data are collected, and, incidentally, supplies the best method so far devised for following the progressive arrival of tracer-laden gas at the producing well and the approaching completion of the project. It involves the calculation of the maximum helium content that would prevail in the produced gas if the tracer-laden gas was injected continuously until this maximum was obtained. If a single open passage prevailed between the injection well and the producing well, in a field such as this one where there was no material change in the quantity of gas in the reservoir, and if no commingling was present, the helium content of the gas from the producing well would rise abruptly to a maximum upon arrival of the tracer-laden gas, would maintain that maximum for a period of time equal to that during which the gas was injected, and then would drop abruptly to the normal level. Instead of this single open passage from the injection well to the producing well, however, there exists something that might approach an infinite number of extremely small passageways. Each of these passageways in the present instance received tracer-laden gas from the injection

FIG. 7. Porosity profiles of all wells except one at which tracer helium appeared.



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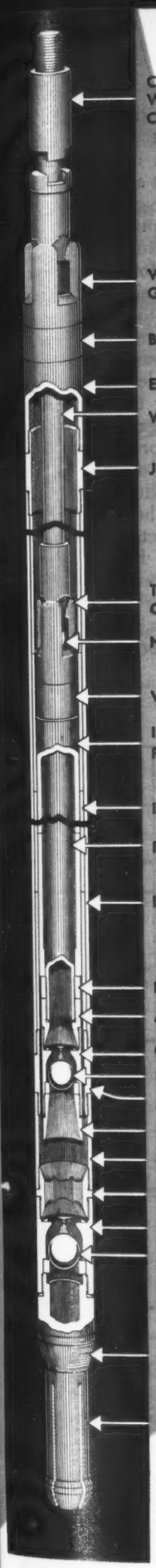

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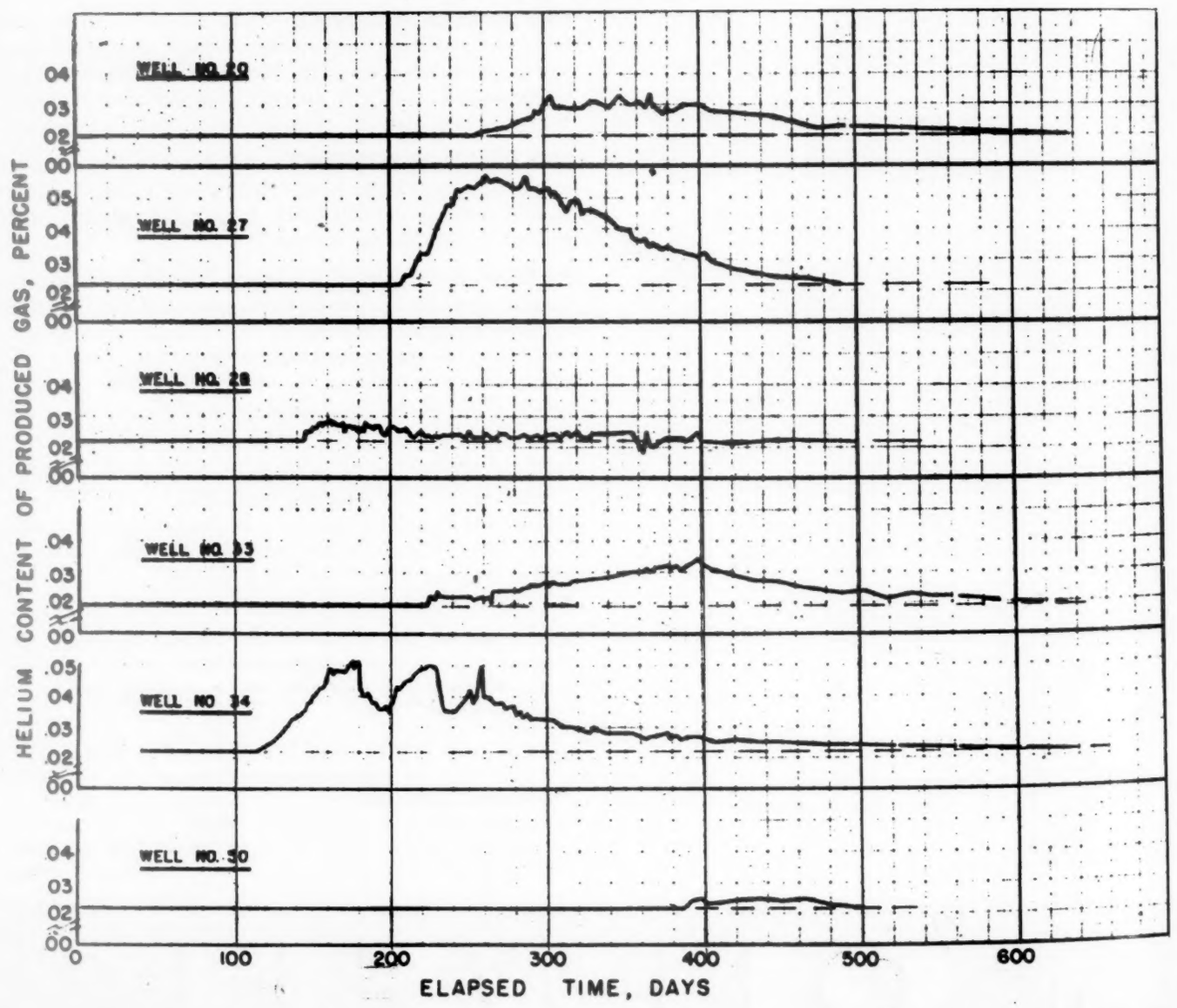
well for the 5.03-day period and was preceded and followed by the normal gas. As the wave-front of tracer-laden gas in each of these small passages reached the producing well, they would begin delivering tracer-laden gas and would continue to deliver it for the 5.03-day period following which they would resume delivering the normal natural gas into the well-bore. Thus, when the wave of tracer-laden gas first reached a producing well through the most permeable passage, this passage would continue to deliver the gas for the 5.03-day period. At that time, if no further tracer-laden gas had reached the well through other passages, the helium content of the produced gas would return to normal, and if it did not return to normal, it was due to the fact that tracer-laden gas then was reaching the well through other passages. On the sixth day of the present test, for example, the tracer-laden gas from the first passage would have become depleted, whereas if it had continued to be delivered from this first passage for a longer period of time (i.e., if tracer-laden gas had been injected for a longer period of time), this helium content would have been superimposed on that appearing through other channels, and the helium content on the sixth day would have been greater than it actually was by the amount that started appearing on the first day. Likewise, for example, on the eleventh day of the present test, the tracer-laden gas from the figurative second passage would have become depleted and any further tracer-laden gas in the produced gas would be due to its arrival through a figurative third passage. If, however, the tracer-laden gas had continued to be delivered from passages 1 and 2, as well as the new arrival through passage 3, (i.e., if tracer-laden gas had been injected for a sufficiently longer period of time) the total helium content of the produced gas on the eleventh day would have been the sum of that appearing on the first, sixth, and eleventh days. Likewise, on the sixteenth day the total helium content would have been the sum of the contents found on the first, sixth, eleventh, and sixteenth days.

By following the foregoing procedure of cascading the helium content each 5 days for the entire period during which tracer-laden gas was produced, and plotting the helium content against time, a graph may be obtained showing pictorially the arrival of the wave-front of injected gas equivalent to that which would have prevailed if tracer helium had been added to the injected gas continuously rather than for the five-day period. Graphs for wells No. 27 and 30 as obtained by the cascading process are shown in Fig. 9. These reveal that, although approximately 100

FIG. 8. Helium content vs. time for gas produced from wells in Shuler field.



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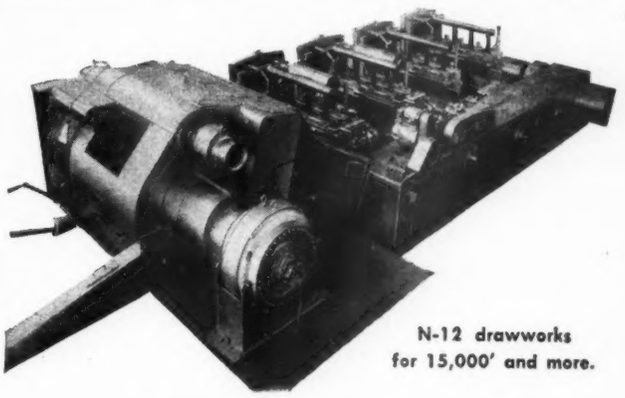

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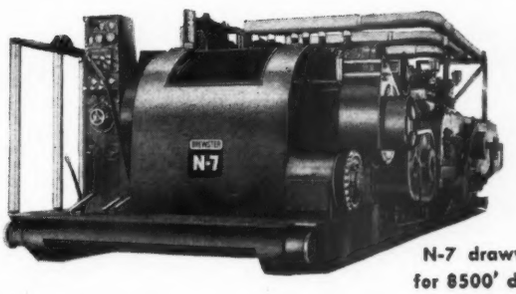

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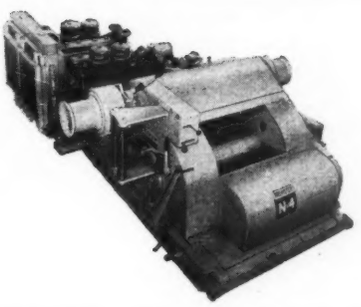

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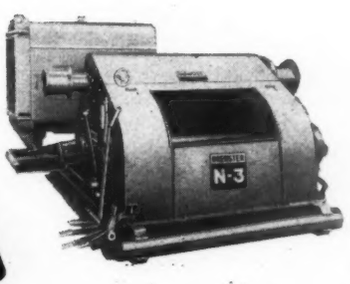

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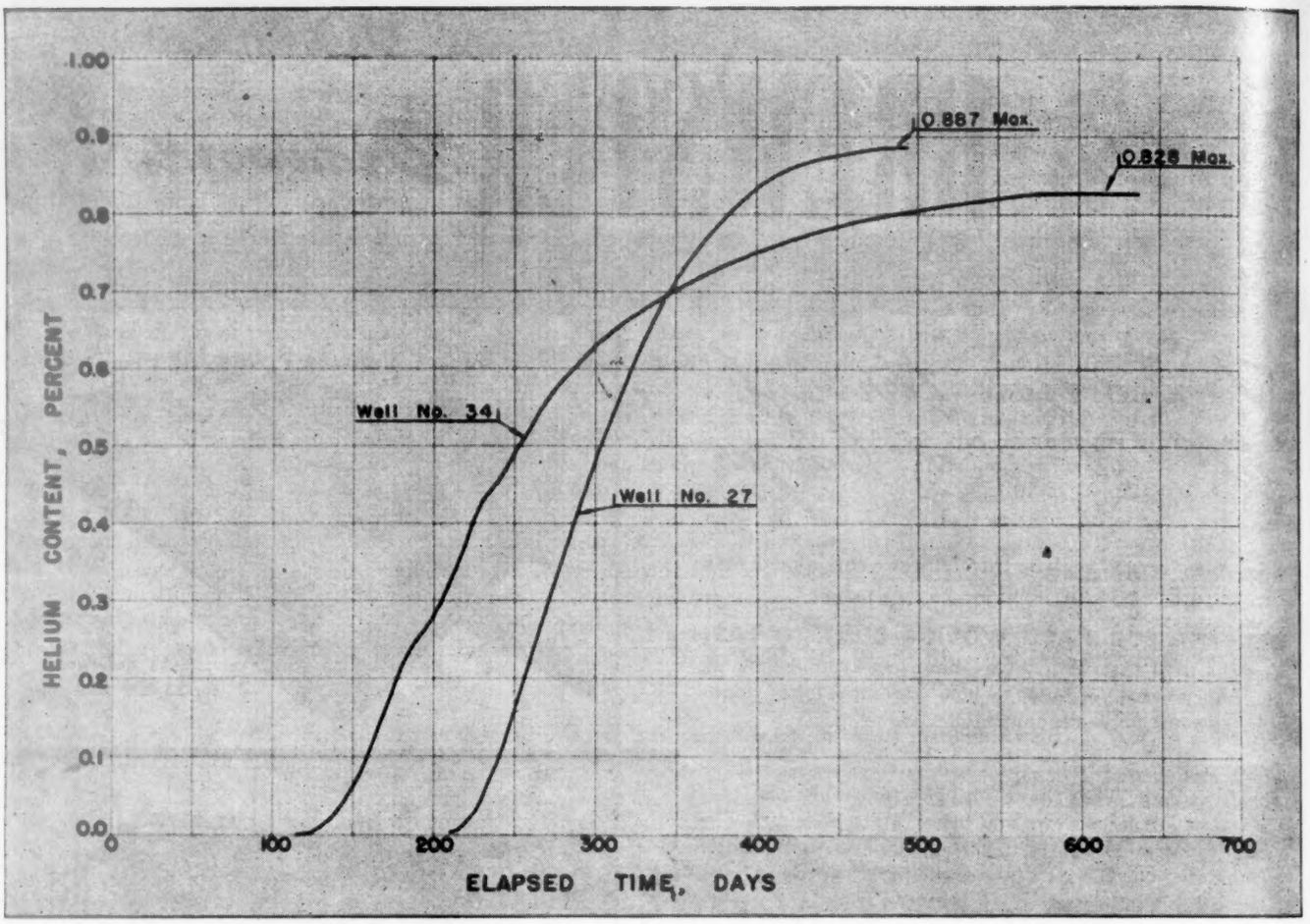

FIG. 9. Helium content vs. time, as obtained by cascading process, Shuler field.

days longer were required for the gas to reach well No. 27 as compared to No. 34, it arrived in a more solid wave-front and reached its maximum content approximately 100 days sooner than well No. 34. Further examples of this cascading process were given in a previous publication.[5]

The graphs comprising Fig. 9 show pictorially the transition from natural gas to injected gas at the start of gas-injection operations, and would permit calculation of the relative amounts of natural gas and injected gas at any stage of the process as discussed in succeeding paragraphs. This is of particular interest in operations where dry gas is injected into a condensate-bearing field to flush the rich gas from the formation. A graph of this type, kept current by cascading the helium content data as collected, would reveal progressively the transition from rich gas to injected gas, and signal the approaching end of economical processing.

The helium content of the produced gas, as obtained by the cascading process, may be used to calculate the relative amounts of injected gas in the produced gas. The cascaded values are the increases only, and their sum must be added to the initial helium content of the gas to obtain its calculated final content. For example, from Fig. 9, the final net increase in helium content at well No. 27 is noted to be 0.887 per cent. The initial helium content was found to be 0.022 per cent, so the increase of 0.887 superimposed on the initial of 0.022 gives a final calculated helium content of 0.909 per cent in the produced gas. This produced gas is a mixture of the natural gas and the injected gas, and as in any simple mixture, its helium content will be directly proportional to the relative amounts of the component parts of the mixture. The weighted average helium content of the injected gas was 1.018 per cent and the initial helium content of the produced gas was 0.022 per cent. Thus, the produced gas of 0.909 per cent helium content was a mixture of two gases containing 1.018 per cent and 0.022 per cent, respectively, helium content. The composition of the mixture may be represented mathematically by:

$$1.018M + 0.022\ (1\text{-}M) = 0.909$$

where

M = mole fraction of tracer-laden gas in produced gas

$(1\text{-}M)$ = mole fraction of natural gas in produced gas

1.018 = per cent helium in injected gas

0.022 = per cent helium in natural gas

0.909 = per cent helium in produced gas

from which

$M = 0.890 = 89.0$ per cent injected gas in the produced gas, and

$1\text{-}M = 0.11 = 11.0$ per cent natural gas in the produced gas

The per cent of injected gas in the produced gas at any stage of the transition may be calculated in a like manner by selecting instead of the final net increase in helium content the increase at the time desired, and repeating the calculations. Almost all natural gases in the United States contain some helium, and it is necessary to use precaution in cascading only the increases above this initial content and then superimposing the sum of the cascaded values back on the initial helium content to obtain the calculated values of helium content of the produced gas at various stages of the process.

The total increase in helium content of the produced gas from each of the wells in the Shuler field was

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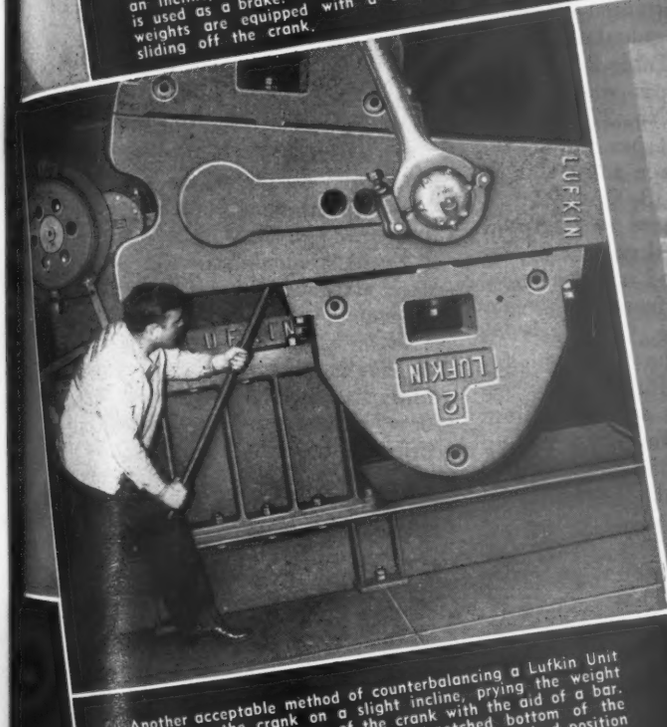

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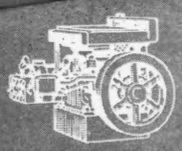
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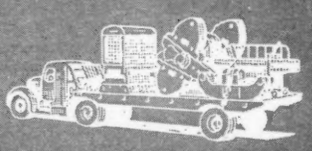
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TABLE 3. Per cent injected gas in the produced gases, as calculated by cascading process, Shuler, Arkansas, field.

Well No.	Total increase in helium content, per cent	Maximum resulting helium content, per cent	Injected gas in produced gas, per cent	Injected gas in produced gas as calculated by alternate method, per cent[2]
1	2	3	4	5
20	0.374	0.394	37.5[1]	37.6
27	0.887	0.909	89.0	83.1
28	0.119	0.141	11.9	13.7
33	0.485	0.504	48.5	52.0
34	0.832	0.854	83.5	73.3
50	0.032	0.054	3.2	5.1

i.e. $1.018M + 0.020\ (1\text{-}M) = 0.394$

$0.998M = 0.374$

$M = 0.375 = 37.5$ per cent

where:

1.018 = per cent helium in tracer-laden injected gas
0.020 = per cent helium in natural gas produced at this well
0.394 = per cent helium in produced gas as obtained by the cascading process
M = mole-fraction of tracer-laden gas in produced gas.

[2] A repetition of data in table 2, column 6, for convenient comparison purposes.

calculated by the cascading process, and the increases are listed in column 2 of Table 3. These values of increase were superimposed on the initial helium contents of the produced gases to give the calculated final helium content of the gas, and these final helium contents are listed in column 3. The calculated percentage of injected gas in the produced gas was calculated from these helium contents as outlined above, and the calculated percentages are listed in column 4. The per cent of injected gas in the produced gas had been calculated previously from volumetric data as listed in Table 2, and for convenient comparison the percentages as listed in Table 2 are repeated in column 5 of Table 3.

Flow Channel Volumes

The volume of the flow channel between the injection well and each of the producing wells can be calculated by use of the helium tracer data as arranged in Fig. 9. The calculations are based on the fact that the injected gas is being produced at essentially the same rate as it is injected, and the volume of injected gas in the formation at any instant is equal to the difference between the total volume injected and the total volume produced. These calculations could be started at the start of gas injection operations, or by putting a marker in the stream of injected gas to start the calculations. The tracer helium is an excellent marker to use in these calculations.

The helium content data of the produced gas when arranged as in Fig. 9 shows graphically the arrival of the wave. According to these data, the flow channel to well No. 27, for example, was flushed completely by the 485th day. In this period, no tracer-laden gas was produced during the first 207 days, but from the 208th to the 485th day, it and subsequently injected natural gas were produced in progressively larger volumes until the maximum rate was attained on about the 485th day. The calculations and data summarized in Table 2 indicated that injected gas from well No. 61 was moving to well No. 27 at a rate of 852, M cubic feet per day; thus, during the 485 days a total volume of 485 x 852, M, or 413,000,000 cubic feet of gas would have entered this flow channel. The total volume of this gas that was produced may be calculated by obtaining from planimeter measurements of Fig. 9 the average helium content of the produced gas during the 485 days. Planimeter measurements showed the average helium content of the produced gas during this period to be 0.354 per cent. By the method of calculation explained earlier, and utilizing the above average of 0.354 per cent helium, the average concentration of the injected gas in the produced gas during the period was

$1.018\ M + 0.022\ (1\text{-}M) = 0.354$

$M = 0.333 = 33.3$ per cent of the produced gas.

The total volume of gas produced at this well per day, according to Table 2, averaged 1025 M cubic feet and thus the total volume of injected gas that was produced during the first 485 days is calculated to be:

485×33.3 per cent $\times\ 1025\ M =$ 166,000,000 cubic feet.

The volume of injected gas in the flow channel as of the 485th day was the difference in these two volumes, or

413,000,000 — 166,000,000 = 247,000,000 cubic feet.

This is the volume that the gas would occupy under the standard conditions. Calculations must be made to determine its volume under the conditions of pressure and temperature prevailing in the formation. The average gas-cap formation pressure in this part of the field is approximately 1400 lb per square inch, and the average formation temperature is approximately 200 F. Under those conditions and assuming that the gas obeys the perfect gas laws, the above 247,000,000 cubic feet of gas would occupy

$$247{,}000{,}000 \times \frac{14.65}{1400} \times \frac{660}{520} =$$

3,280,000 cubic feet

This 3,280,000 cubic feet is the calculated volume of the flow channel between injection well No. 61 and producing well No. 27, Fig. 2.

Similar calculations were made for each of the additional wells at which the tracer helium appeared, and the calculations are summarized in Table 4. The summarized data in this table indicate that the total volume of all flow channels carrying gas away from injection well No. 61 during the present test was 10.6 million cubic feet.

* * *

TABLE 4. Volume of flow channels from injection well to producing wells, Shuler, Arkansas, field.

Well No.	Length of period to flush flow channels, days	Average helium content of produced gas during period in column 2, per cent	Average injected gas in produced gas during period of column 3, per cent[1]	Rate of production of gas from well MCF, per day	Volume of injected gas entering channel during period of column 2, million cubic feet[2]	Volume of injected gas produced from flow channels during period of column 2, million cubic feet[3]	Volume of gas in flow channel million cubic feet[4]	Volume of flow channel, MFC[5]
1	2	3	4	5	6	7	8	9
20	635	0.166	14.6	612.	146	57	89	1180
27	485	0.354	33.3	1,024.9	413	166	247	3280
28	485	0.080	5.8	768.6	51	22	29	390
33	639	0.201	18.2	570.9	190	66	124	1650
34	635	0.468	44.8	1,485.6	692	423	269	3570
50	475	0.0252	0.32	1,756.6	43		40	530

[1] Calculated as shown in reference [1] of table 3.

[2] Obtained as the product of the columns 2 and 5 above, and column 5 of table 3.

[3] The product of columns 2, 4, and 5, above.

[4] Column 6—column 7, cubic feet (when measured at standard temperature and pressure conditions)

[5] The volume that would be occupied by the volumes in column 8 if these volumes were reduced to the conditions of temperature and pressure existing in the reservoir, (1400 psi and 200F)

Optimum Use of Coring, Electric Logging, and Other Testing Methods in Exploratory Wells†

JOHN E. WALSTROM*

Part 2—Conclusion

Exploratory Drilling Programs

The methods of formation evaluation that are reviewed in Part I are the basic elements of the exploratory drilling program. In addition to a knowledge of the results obtained by the several methods of formation evaluation, it is necessary to determine which methods lend themselves best to the conditions to be encountered, and the optimum combination of well logging techniques to be employed in order to economically obtain the desired amount of information. When a complete exploratory program is formulated, many factors must be taken into consideration such as the type of drilling fluid to be employed, the nature of the formations to be encountered, probable total depth, and expected hole conditions. Although much of the logic contained in this analysis of exploratory drilling programs is used intuitively by those directly responsible for such operations, it is believed that an approach from the non-intuitive standpoint is worthwhile. Such a study may serve as an outline to guide management in evaluating the recommendations made by the technical staffs of the exploratory and exploitation divisions of their organization. It may also serve as a review for those who are closely connected with the problem, and who realize that the programs adopted are sometimes apt to become too rigidly standardized due to routine usage.

It should not be construed that every individual exploratory drilling program will, as a result of the classification presented here, be immediately and readily catalogued, for instance, as type II-B. A program decided upon at the outset may of necessity be changed during the course of drilling due to factors that were not initially anticipated. The charts are better described as a classification of the principles used in designing programs, rather than as a classification of individual programs. Furthermore, the logging and testing methods used often deviate from a more or less accepted practice due to a particular or local condition. For instance, in a certain area the presence of a geologic formation known to cause extremely bad hole conditions might necessitate the use of a drilling fluid that is not compatible with a good interpretation of mud logging or sidewall sampling data.

The present study has avoided the inclusion of specific data concerning the limits within which a practical and economical functioning of the various coring, testing, logging, and cementing techniques is obtained. Examples of such limits are: The maximum safe depth for open hole formation testing; the maximum open hole formation test interval for reliable formation evaluation; per cent successful water shut-off tests, as a function of depth, or the probability of getting water shut-offs as a function of the distance from the cementing point to the water shut-off point. The reason for omitting specific limits is that they vary considerably from one area to another and, furthermore, what one operator may consider practical and economical, another may not. For any particular area, however, a study of the available statistics concerning such limits would undoubtedly be both interesting and profitable.

System of Classification

The progress of an exploratory well may be divided conveniently into the intervals of drilling between consecutive electric log surveys. It is interesting to study the ways in which the formations lying in any one such interval may be evaluated. One very complete and thorough way is as follows: (1) A commercial mud logging service is used. (2) Significant oil shows are cored. (3) The electric log is run. (4) Interesting horizons on the electric log not otherwise evaluated are sidewall sampled. (5) On the basis of the results of the mudlog, cores, electric log, and sidewall samples, formation tests are made either on the way in, on the way out in open hole, or on the way out inside casing of stub liner. A second way of evaluating such an interval would be to proceed similarly but without mud logging, and a third way, even more abbreviated, would be to dispense also with coring and depend on the results of the electric log and sidewall cores to indicate if and where formation tests should be made or casing run.

The above discussion summarizes briefly the principles underlying the classification selected for the charts. The three charts 1, 2 and 3 are classified on the basis of when and how the formation testing is done. The three sub-classifications A, B, and C represent respectively: The complete set of methods discussed above; without mud logging; and without mud logging and coring. Generally speaking, the number of techniques employed is determined by the amount of information available. Such information may consist of other electric logs in the area or known stratigraphic or structural conditions.

It should be noticed that all of the programs outlined in the three charts include as fundamental premises:

(1) That the electric log is always run.

(2) That interesting horizons on the electric log not evaluated by other methods are sidewall sampled.

(3) That an interval is formation tested if cores or logs indicate it to be possibly oil or gas productive.

In view of the stakes involved in an exploratory operation, it is believed that these premises are warranted.

The real risk taken in omitting mud logging and coring is that a commercially productive formation may not appear sufficiently interesting on the electric log to warrant further testing. This emphasizes the necessity for a competent electric log interpretation. Certain oil producing sands that are silty and contain salty interstitial water may look very mediocre on the electric log but still may yield commercial production. If mud logging is used and a show is obtained opposite

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such an interval, testing would be indicated and the interval more adequately evaluated.

If any uncertainty as to formation fluid content still remains after the logging and coring data have all been obtained, it is ordinarily judicious to make a formation test. Even then, needless to say, some holes have been abandoned with some remaining questions still unanswered. The ultimate goal in the development of formation evaluation techniques should be to increase the efficiency of these tools until the probability of missing a commercially productive horizon has been reduced as much as practicable.

The number of testing and logging methods that are actually used at one time or another while evaluating the formations penetrated by an exploratory well bore, depends on: (1) Whether method A, B, or C is chosen, and (2) on the number of oil or gas shows obtained requiring further investigation. It is interesting to express analytically the many combinations of methods that may actually arise in practice. Let M denote mud logging, C coring, L electric logging, S sidewall sampling, and T testing. Then, disregarding for the moment the order of application of the methods, or the possible use of a method more than once in any interval, the number of combinations of methods that can be used are:

	A Full set of methods employed	B No mud Logging	C No mud Logging or coring
1.	MCLST	CLST	LST
2.	MLST	LST	LT
3.	MCLT	CLT	LS
4.	MCLS	CLS	L
5.	MLT	LT	
6.	MLS	LS	
7.	MCL	CL	
8.	ML	L	

Where: M = mud logging
C = coring
L = electric logging
S = sidewall sampling
T = formation testing

Furthermore, each of the above combinations of methods can be classified further according to the order of application. For instance, the combination MCLST may also be practicably used in the orders MCTLS and MTCLS. It also frequently happens that one method may be applied more than once in any particular interval of hole. This is illustrated by MCTLST and MCTCLST. These variations are all included in the single combination 1A in the table above.

Although the considerations of the last paragraph may appear somewhat redundant, they are included in order to emphasize the great diversity of operational procedures that may arise in practice even after a general exploratory program has been decided upon.

Drilling Program Charts

The three general types of exploratory testing programs are shown in Charts 1, 2, and 3. The subject matter of the charts is self-explanatory and includes an enumeration of the advantages, disadvantages, and applications of the three general methods of testing. Although testing on the way in is in many instances desirable, there are areas in which it may not be the best way to proceed.

Before selecting a particular program, there are several very important factors that should be taken into consideration. These may be outlined as follows:

1. Characteristics of the objective zone.
   A. Type of geologic play: Stratigraphic trap, fault accu-

CHART 1. Test on way in.

	A	B	C
Variations of general program on basis of the number of techniques used for formation evaluation	1. Install complete mud logging or cuttings analysis service. 2. Obtain ditch samples for paleontological determinations. 3. Drill ahead and core if: (a) significant oil shows; (b) drilling breaks near objective interval. 4. Run electric log. 5. Sidewall sample as necessary. 6. Formation test as indicated.	1. Drill ahead and core if: (a) significant oil shows on ditch; (b) drilling breaks near objective interval. 2. Obtain ditch samples for paleontological determinations. 3. Run electric log. 4. Sidewall sample as necessary. 5. Formation test as indicated.	1. Drill ahead without coring. 2. Obtain ditch samples for paleontological determinations. 3. Run electric log. 4. Sidewall sample as necessary. 5. Formation test as indicated.
Variations of procedure on basis of drilling practices	1. Coring may be done in reduced hole or full hole. 2. Sidewall samples may be obtained on logging cable or drill pipe and may be cored or punched depending on the type of formation. (This also applies to 1-C). 3. Formation tests may be obtained using a shoulder or sidewall packer tool. (This may also apply to 1-C).		1. Drilling may be in 500–1000 foot stages of reduced hole followed by running electric log, then reaming and testing any favorable intervals on basis of log or ditch shows. This method may necessitate plugging. 2. Drilling may be in full hole, reducing hole on a significant ditch show or drilling break.
General advantages	1. Bottom hole tests in open hole on the way in are often more representative of true formation fluid because: (a) Minimum contamination of formations by drilling fluid, filtrate, or cement. (b) The possibility of a failure of the cement bonds behind the casing is avoided. (c) The possibility of a plug leaking, or the tool slipping off a plug, when testing in open hole on the way out are avoided. (1-C, however, may require plugging). 2. Bottom hole tests of intervals of one to three hundred feet on the way in are often considerably less expensive than testing equivalent intervals inside casing on the way out and particularly so if water shut-offs are obtained above and below the interval to be tested. 3. More assurance of evaluating the shallower formations, since, if the well is not tested on the way in and is completed successfully in a deep objective, the shallower tests are very seldom made until the well becomes uneconomic, or must be made in another well. 4. Casing and cementing costs have not been incurred before the evidence of production is established.		
General disadvantages	1. More time is required to reach the deepest lying objective than when testing on the way out. 2. More danger of losing the hole or fishing before reaching total depth than when testing on the way out. This may require sidetracking and redrilling before the lowermost objective can be evaluated. 3. Tests cannot always be made in the desirable intervals. Better control of the interval to be tested is obtained by selective gun perforating. 4. Formation tests are usually limited to short duration due to danger of sticking tool. Testing inside casing allows swabbing or bailing and making a production test with considerably less danger. 5. In some areas, open hole testing may be dangerous below a certain depth due to sticking of the packer. 6. When drilling is rapid and the sands are thin, the bit may pass through the showings before the hole size is reduced. This would preclude the use of a shoulder type packer.		
Applications	1. The general procedure of testing on the way in is best applied to wells drilled in highly unevaluated areas where several formations may prove to be of commercial value. 2. This general type of program is also adapted to wells of the semi-exploratory nature drilled on the edge or near oil fields in which several commercial formations are known to be present.		

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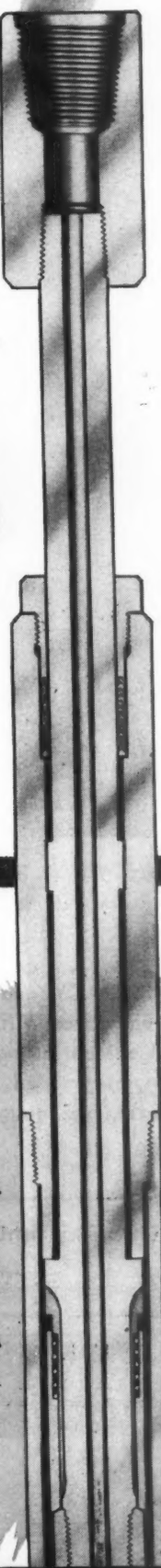

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mulation, or anticlinal structure.

B. The number, estimated depth, thickness, and distribution of the possibly productive intervals that may be penetrated.

C. The physical nature of the objective zones: Unconsolidated sand, hard sandstone, fractured chert or shale, porous limestone, or fractured limestone. Heavy oil, light oil, or gas. High pressure zones or low pressure zones.

D. The chemical nature of the formations: Salt, anhydrite, or sulfur.

2. General subsurface considerations.
   A. Number of available well logs and histories in the area.
   B. Probable accuracy of electric log correlations.
   C. Degree of known faulting.
   D. Accuracy of available seismic data.
3. Drilling technique.
   A. Presence of high head waters.
   B. Possibility of encountering zones of lost circulation.
   C. Possibility of encountering zones of caving shale.
   D. Presence of known gas zones overlying objectives.
   E. Presence of known productive oil zones overlying objectives.
4. The effect of the type of drilling fluid used on the formation evaluation methods.

In order to illustrate the manner in which the characteristics of the formations influence the choice of exploratory drilling program, two programs used by a particular operator will be examined.

1. Gulf Coast operations.
   A. Mud logging usually is employed from some selected depth between 2000 and 5000 ft to total depth.
   B. The hole is drilled approximately 9000 ft with no coring or testing.
   C. The electric log is run at this depth, and approximately every 1000 ft thereafter.
   D. If good mud logging shows have been obtained, or if good electric log shows are indicated, the percussion type sidewall sampling tool is used to obtain samples in all of the interesting horizons. This procedure is repeated after each electric log survey.
   E. After reaching total depth, which is generally of the order of 10,000 ft to 13,000 ft, a decision is made whether or not to set casing on a basis of,
      1. Mud logging shows
      2. Electric log interpretation
      3. Results of sidewall samples
   F. In this area and in these formations it is usually possible to tell whether or not a hole will make an oil well on the basis of the above three techniques. Casing is cemented at the base of the deepest possible productive sand and the best looking horizons usually are tested first, regardless of whether they lie above or below other interesting sands. If all the interesting horizons look equally good, tests are made from the bottom up. All production is from sands.

It has been decided that the above exploratory drilling program is most economic and most diagnostic for the following reasons:

(1) Any of the thin sands in the long Miocene section may prove to be commercially productive in an exploratory well.

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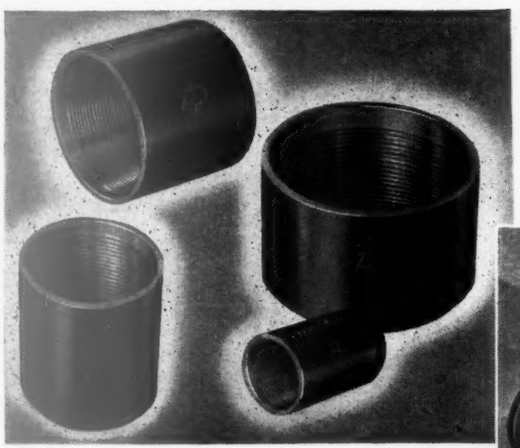

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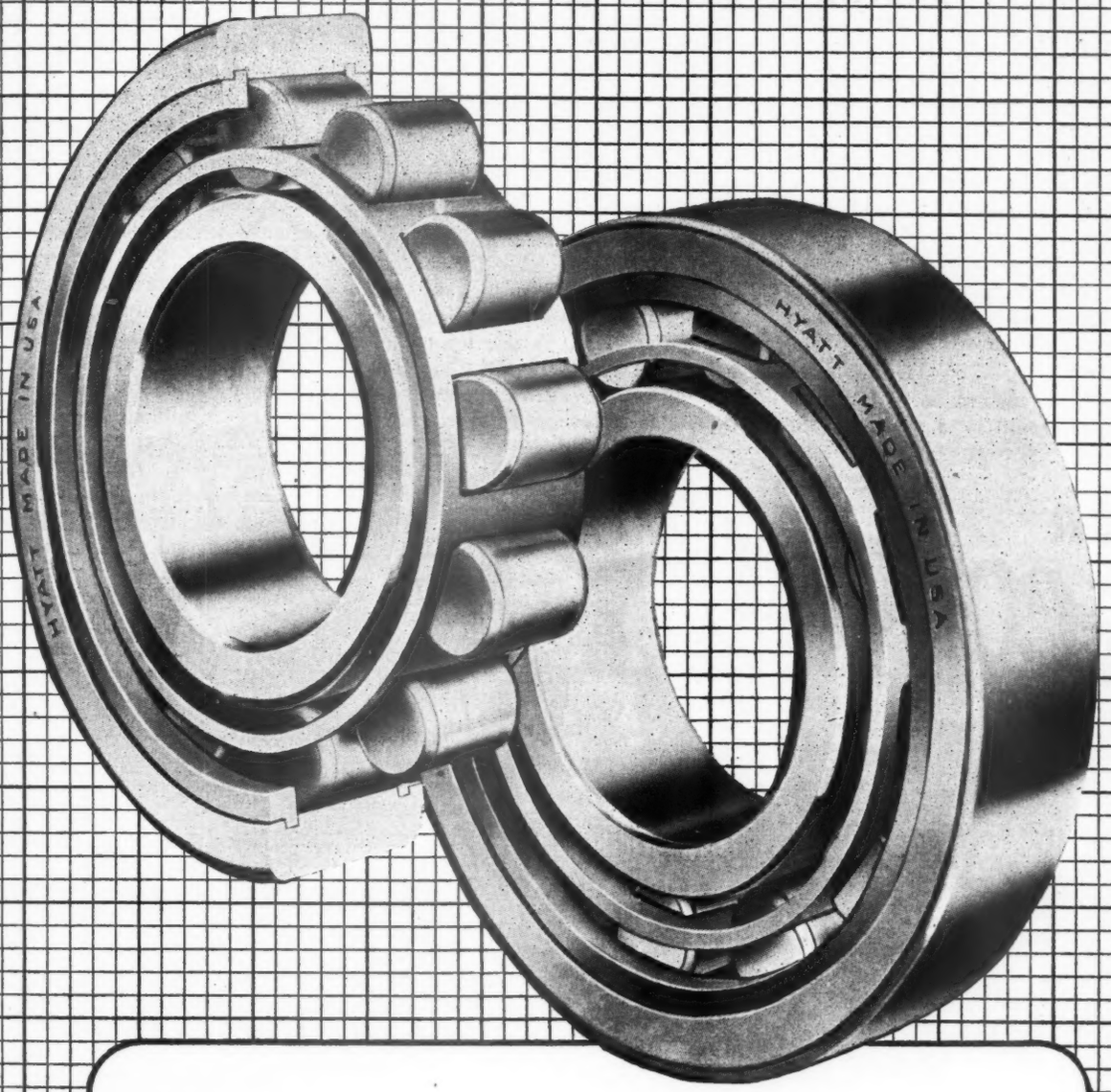

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(2) In this area it is dangerous to make a drill stem test in open hole, because the soft unconsolidated formations tend to slough into the hole.

(3) Little or no coring is done because the sands are thin and the drilling fast. This situation often results in the sand being penetrated completely before a core can be taken.

(4) The electric log in the Gulf Coast Miocene formations is very diagnostic of fluid content.

(5) Due to the soft formations, the percussion type sidewall sampling device functions very satisfactorily, yielding good recovery. It is interesting to note that the sidewall samples obtained are analyzed with a fluoroscope. This technique is used to locate gas-oil contacts and oil-water contacts.

From the above, it is clear that the thickness, distribution, number and hardness of the expected objective sands make testing on the way out inside casing an economical and practical program. It is also important to note that the dependability of the electric log interpretation in these formations also influences this choice.

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In this area, three productive formations are present. In a typical deep Tuscaloosa well the Wilcox in the Eocene is encountered at about 4,000 ft and the Basal Tuscaloosa in the Upper Cretaceous at approximately 10,000 to 11,000 ft. The third possibly productive horizon is the Eutaw Sand, which also lies in the Upper Cretaceous and is found approximately 1500 ft above the Basal Tuscaloosa. Cores usually are taken in these zones, regardless of whether or not any mud logging shows are obtained. Coring is done in reduced hole and if the cores indicate possible production, open hole formation tests are made using a wall type packer. The packer is set inside the reduced hole in order to obtain maximum clearance while lowering and pulling the tester. Tests are ordinarily limited to a 100 or, at the most, a 200-ft interval.

The Eocene and Cretaceous formations are harder than the Gulf Coast Miocene formations, which allows testing more safely in open hole. Percussion sidewall samples are ordinarily taken as supplementary data, particularly in the Wilcox. Although the electric log is valuable, it is not as diagnostic as in the Gulf Coast Miocene because of the extremely high salinity of the interstitial water in some of the horizons. About three electric logs are made during the drilling of a Basal Tuscaloosa exploratory well. The first log is made after penetrating the Wilcox sand, because it is so easily invaded by drilling fluid filtrate. Cuttings analysis is more effective in this area due to the larger cuttings that are obtained in the harder formations.

One important point emphasized by this operator is that a mud logging show is seldom drill-stem tested without first taking a core, or at least obtaining sidewall samples in the interval. In other words, a formation test is never made on the basis of a mud logging show alone. This procedure eliminates the testing of mud logging shows obtained in intervals that a conventional core might show to be noncommercial.

From the above, it is clear that exploratory drilling operations in the Eocene and Upper Cretaceous in Mississippi lend themselves very well to testing on the way in. The harder formations and more definite objectives make it possible to carry out such a program economically. Furthermore, the less diagnostic electric logs and sidewall samples lower the efficiency of a program that depends heavily on these services.

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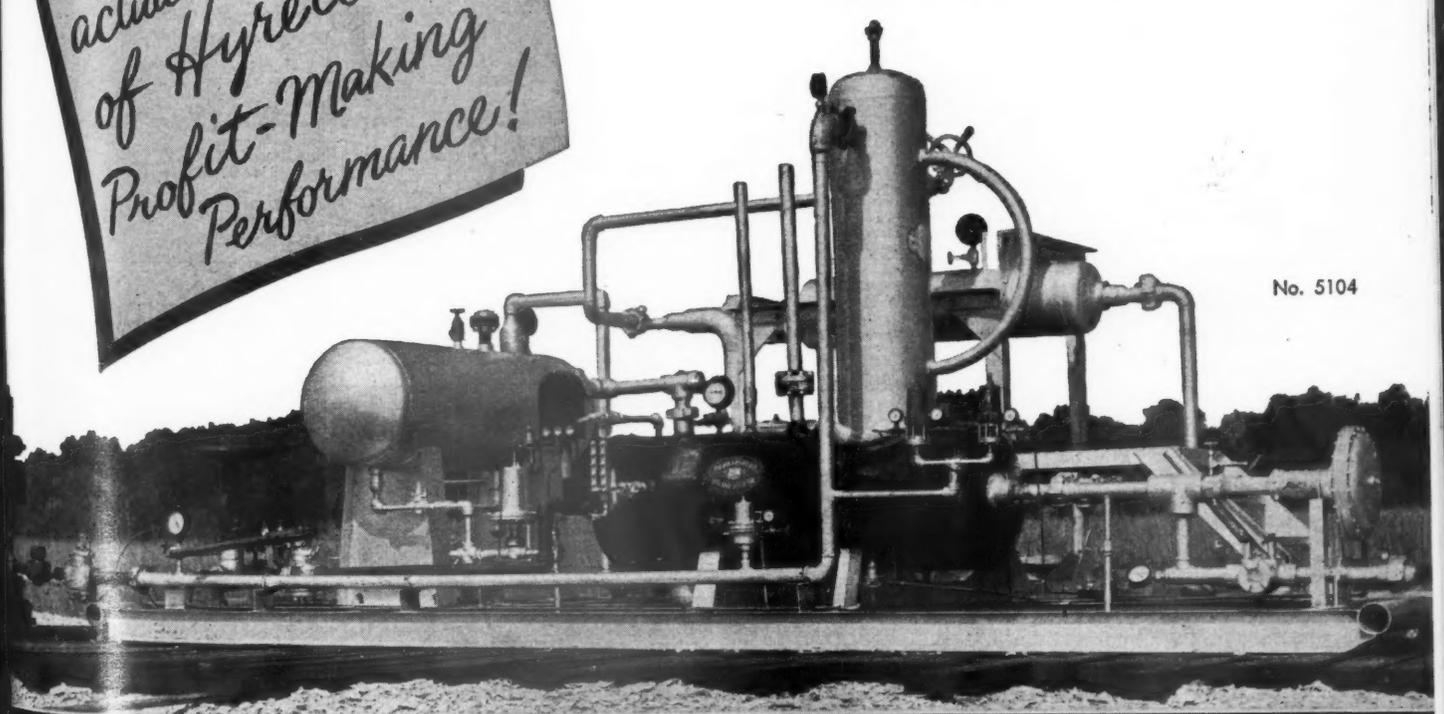

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CHART 2

TEST ON WAY OUT IN OPEN HOLE

	A	B	C
Variations of general program on basis of the number of techniques used for formation evaluation	1. Install complete mud logging or cuttings analysis service. 2. Obtain ditch samples for paleontological determinations. 3. Drill ahead and core if: (a) significant oil shows; (b) drilling breaks near objective interval. 4. Run electric log. 5. Sidewall sample as necessary.	1. Drill ahead and core if: (a) significant oil shows on ditch; (b) drilling breaks near objective interval. 2. Obtain ditch samples for paleontological determinations. 3. Run electric log. 4. Sidewall sample as necessary.	1. Drill ahead without coring. 2. Obtain ditch samples for paleontological determinations. 3. Run electric log. 4. Sidewall sample as necessary.
Variations of procedure on basis of drilling practices	1. Coring and drilling are done in full hole since no formation tests are made on the way in. 2. Sidewall samples may be obtained on logging cable or drill pipe and may be cored or punched depending on the type of formation. 3. Formation tests are made on the way out using a sidewall packer. 4. A caliper survey is required for determining the proper position of the sidewall packer. It is ordinarily run after the last electric log survey.		
General advantages	1. Casing and cementing costs have not been incurred before the evidence of production is established. 2. The total depth of the well is reached more quickly and economically than when testing on the way in. Thus, if the deepest objective is commercial, an economical well can be completed at a minimum cost. 3. There is less danger of losing the hole before total depth is reached than when testing on the way in. 4. If the hole is lost while testing on the way out, the objective sands lying at maximum depth have already been evaluated. In this case it may be desirable to abandon the hole. However, if the hole is lost while testing on the way in, it is necessary to redrill before evaluating the deepest objectives. 5. Testing on the way out eliminates the necessity of drilling in reduced hole on the way in.		
General disadvantages	1. Tests may be uncertain because the formations are exposed to mud, filtrate, and cement for longer periods than when testing on the way in. 2. Testing in full hole on the way out is not as definitive as bottom hole testing on the way in, since the cement plug can leak or slide down the hole, or the tail pipe can slip off the plug. 3. Open hole testing is not as safe as testing inside casing. 4. Placing cement bridges contaminates the mud increasing the cost of mud treatment. 5. In some areas open hole testing may be dangerous below a certain depth due to sticking of the packer. 6. If deepest objective is commercial, shallower formations remain unevaluated since further testing is often dispensed with. 7. Testing in open hole on the way out may be impossible due to caving or washing out of the formations preventing the packer from holding.		
Applications	1. Testing on the way out in open hole is applicable to exploratory wells in which a deeper objective is found to be non-productive or absent, and in which shallower formations, although previously believed to be not as attractive, have given some evidence of possible oil or gas accumulation.		

CHART 3

TEST ON WAY OUT INSIDE CASING

	A	B	C
Variations of general program on basis of the number of techniques used for formation evaluation	1. Install complete mud logging or cuttings analysis service. 2. Obtain ditch samples for paleontological determinations. 3. Drill ahead and core if: (a) significant oil shows; (b) drilling breaks near objective interval. 4. Run electric log. 5. Sidewall sample as necessary.	1. Drill ahead and core if: (a) significant oil shows on ditch; (b) drilling breaks near objective interval. 2. Obtain ditch samples for paleontological determinations. 3. Run electric log. 4. Sidewall sample as necessary.	1. Drill ahead without coring. 2. Obtain ditch samples for paleontologica determinations. 3. Run electric log. 4. Sidewall sample as necessary.
Variations of procedure on basis of drilling practices	1. Coring and drilling are done in full hole since no formation tests are made on the way in. 2. Sidewall samples may be obtained on logging cable or drill pipe and may be cored or punched depending on the type of formation. 3. Formation tests are made on the way out by selective gun perforating after cementing pipe. It is considered good practice to obtain water shut-offs above and below each interval to be tested.		
General advantages	1. Can swab or bail and make a definitive production test of an interval which in some cases may be more representative of the formation fluid content. 2. The total depth of the well is reached more quickly and economically than when testing on the way in. Thus, if the deepest objective is commercial, an economical well can be completed at a minimum cost. 3. If the hole is lost while testing on the way out the objective sands lying at maximum depth have already been evaluated. In this case it may be desirable to abandon the hole. On the other hand, if testing on the way in, it would be necessary to recover the fish or redrill before evaluating the deepest objective. 4. Less probability of sticking packer inside casing than in open hole. 5. Can test a very long section of several hundred feet at one time if necessary. 6. Intervals to be tested can be selected as desired on basis of electric log. 7. There is less danger of losing the hole before total depth is reached than when testing on the way in. 8. Testing on the way out eliminates the necessity of drilling in reduced hole on the way in.		
General disadvantages	1. Tests may be uncertain because the formations are exposed to mud, filtrate and cement for longer periods than when testing on the way in. 2. Casing and cementing costs incurred before production is evidenced. 3. Testing an interval of less than 200 feet inside casing on the way out is usually more expensive than testing the equivalent interval in open hole on the way down. 4. Considerable difficulty may be encountered when testing or completing in an unconsolidated sand through gun perforations due to sand trouble. 5. Difficulty of establishing water shut-offs is sometimes considerable. 6. If deepest objective is commercial, shallower formations remain unevaluated since further testing may often be dispensed with.		
Applications	1. Exploration at depths considered unsafe for the open hole type of tester. See text. 2. Salvage in shallow sands after setting pipe for a deep objective which proves to be noncommercial. 3. Exploration in interbedded oil sands and wet sands. 4. Shallow exploration with multiple objectives where cost of pipe may not exceed cost of several tests. 5. Exploration in areas in which the electric log is diagnostic of the fluid content.		

If some horizons remain unevaluated after reaching total depth, and after having diligently employed the open hole testing methods, casing is set and drill-stem tests made in these intervals on the way out.

Exploration in Limestone

As exploration in limestone formations differs considerably from that in sandstone formations, it is well to include a discussion of some of the factors relating to the detection of oil in limestone exploratory wells. In a discussion with a representative of an operator who has had considerable experience with limestone operations, the following criteria for formation evaluation were advanced as being reasonably correct:

A. Limestone wells in which circulation is not lost.

(1) A commercial mud logging service should be employed on all limestone exploratory wells, since almost invariably the drill cuttings returned from an oil zone show fluorescence. Such fluorescence is considered to be a more reliable indication of oil than that obtained by any of the other testing methods, with the exception of drill-stem testing.

(2) When an oil zone is penetrated, there also is often a show of gas in the drilling fluid that can be detected readily by a mud logging technique. However, the lack of a gas show does not condemn a zone, since oil zones have been penetrated with no resulting gas show in the drilling fluid.

(3) From a standpoint of distinguishing between oil and water bearing intervals, the conventional electric log is almost useless in limestone exploratory wells, but may be used to some extent in a quantitative manner after a field has been discovered and experience with the electric logs obtained. MicroLogs assist in determining what intervals of the limestone section are porous.

(4) In case there is doubt as to the fluorescence of drill cuttings, sidewall samples are obtained.

(5) When drill-stem testing limestone formations in which circulation has not been lost and there have been some indications of oil, sidewall packers are set and swabbing is continued for as many hours as necessary.

B. Limestone wells in which circulation is lost.

(1) Although a commercial mud logging service is employed, cuttings are not normally available due to lost circulation.

(2) The regular procedure in case of lost circulation is to sidewall sample to determine if there is any fluorescence.

(3) If some fluorescence is indicated, sidewall packer tests are made, but usually of moderate duration. The shorter testing time is used due to the danger of sticking the packer on account of the lost circulation condition.

(4) If the sidewall samples are fluorescent but circulation loss has been so great that diagnostic drill-stem test results are not obtained, it is then necessary to decide whether or not to set casing and make a longer test. This important decision is made by taking into consideration all the factors that bear on the possibility of finding oil in the zone.

California Programs

As in other parts of the country, various types of exploratory drilling programs are used in California, depending on the area and the preference of the operator. In order to be complete, it is desirable to include a specific example of one California exploratory drilling program that has proven to be economical and efficient. The particular drilling program chosen as an example is essentially the I-A type (testing on the way in). It was employed in the drilling of a well to primary objective sands in the Upper Miocene. Due to the known geological conditions above 7000 ft, an abbreviated program was employed to this depth. The main features of this program are as follows:

(1) After cementing casing below fresh water surface gravels at about 1000 ft, an 11-in. hole is drilled to 7000 ft taking ditch samples and spot cores below 3500 ft for paleontological and geological information. All promising sands indicated by the electric log are sidewall sampled.

(2) A mud logging service is installed at 7000 ft, and all subsequent hole is logged for oil and gas shows. Whenever a significant oil show is encountered, a core is taken in reduced hole and coring is continued as long as oil sand is recovered. All cores are analyzed for porosity, permeability, formation factor, and fluid content.

(3) If it is not possible to determine the potentialities of the sand from these data, formation tests are made, if hole conditions permit.

(4) If the primary objective sand is cored and found to be oil bearing but to have a low permeability, consideration is given to cementing casing and changing to oil base drilling fluid before coring more than 30 ft into the sand.

(5) If the primary objective sand is found to be wet, and no other attractive measures have been encountered, the hole is deepened about 1000 ft below the top of primary objective sand, in order to make certain that the section contains nothing of value.

(6) Prior to abandonment, all promising sands not previously cored or tested are sidewall sampled.

Cost of Formation Evaluation

Whether it is decided to test on the way in or on the way out may depend, as previously demonstrated, on the characteristics of the geologic section. It is not always possible, however, on this basis alone to discriminate between the advantages to be gained by using one or the other of these programs. The formations may lend themselves as well to testing on the way in as to testing on the way out. This situation may arise when a very promising deep primary objective is overlain by several formations, that although not nearly as promising, may require further evaluation. In this case, should the added time and added danger of losing the hole while testing be incurred by testing on the way in before evaluating the primary objective? Should the heavy deep hole drilling equipment be used in this somewhat uneconomical way to explore at shallow depths, or should a separate hole be considered for such exploration? On the other hand, however, more representative tests can be obtained in the shallower formations when testing on the way in. They can often be tested at much less expense than when testing in open hole or behind casing on the way out. Many tests behind casing become very expensive due to the dif-

ficulty of obtaining water shut-offs above and below the intervals to be tested.

From the above it is clear that when the type of program selected is not established by subsurface conditions, the decision should then depend on a comparison of the cost and efficiency of the methods. The efficiency of the methods is carefully considered in the three charts under the sections entitled "Advantages" and "Disadvantages."

A significant comparison of the costs incurred using the various formation testing methods outlined in charts 1, 2, and 3 is very difficult to establish, as innumerable considerations bear upon the problem. Attempts to set up a significant comparison on the basis of testing an entire geologic section have failed for this reason. Furthermore, such a comparison would only be of significance for the particular geologic section chosen. It is, however, believed that a significant comparison of these costs can be made if it is limited to the testing of one interval at a particular depth.

The interval chosen for considera- is a 100-ft interval at a depth of 8000 ft. The interval consists of interbedded sandstones and shales. In each instance, the "A" type of program is utilized. In each instance a good mud logging show is obtained at 8000 ft after which 100 ft of oil sand, and shale are cored. The costs are expressed in rig-time days and the service charges for the formation tester, core barrel, and gun perforator are omitted. The interval is tested in the following four ways:

1. Test on the way in. Method I-A. (reduced hole test)
   a) Wire-line core 100 ft of reduced hole.
   b) Make shoulder formation test or sidewall test in reduced hole.
   c) Ream 100 ft of reduced hole.

   Total rig time above operations —3½ days.
2. Test on the way in. Method I-A. (full hole test)
   a) Conventional core 100 ft of full hole.
   b) Make sidewall packer test.

   Total rig time above operations —3½ days.
3. Test on the way out in open hole. Method II-A.
   a) Conventional core 100 ft of full hole.
      (Continue operations to total depth)
   b) Lay cement bridge in hole.
   c) Make sidewall packer test.

   Total rig time above operations —5 days.
4. Test on the way out inside casing. Method III-A.
   a) Conventional core 100 ft of full hole.
      (Continue operations to total depth and set casing)
   b) Squeeze and obtain water shut-off below interval.
   c) Squeeze and obtain water shut-off above interval.
   d) Gun perforate horizon to be tested.
   e) Make formation test inside casing.

   Total rig time above operations—8 days.

It is to be noted that the test made inside the casing is most expensive in spite of not attributing the cost of the casing to the operation. The latter cost is, of course, a very appreciable cost, but was omitted from the cost evaluation, as it is very difficult to determine for the general case what portion of this cost should be attributed to any one test.

To illustrate the indeterminateness with which the cost of the casing can be broken down consider the following: If the test is successful and commercial production results, casing will be set in any case and the cost of the casing would be involved in all four instances. The over-all economics would then not differ appreciably for

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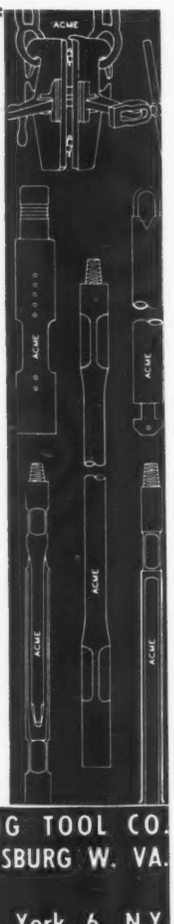

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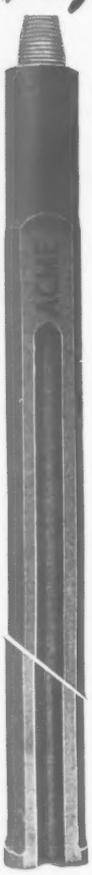

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the four methods. If all tests give evidence of noncommercial production, however, then most certainly the cost of the casing should be included in the cost of testing. Known production overlying the interval of exploration would also modify the proportion of the cost of the casing that should be charged to the testing cost. Statistics indicate, however, that in an exploratory operation, the chances are far more of not finding oil than finding it. Thus, the cost of running pipe in the hole in order to test on the way out must certainly be chargeable to a great extent to the cost of testing. When deciding to run casing for the purpose of testing on the way out, not only should the probability of finding oil be considered, but also the probability of missing an oil field. In fact, this should be considered before it is decided to employ a program involving testing on the way out.

To summarize, the type of testing program adopted depends on the answers to the following questions:

(1) How do the subsurface conditions lend themselves to the various methods of testing?

(2) What is the relative efficiency of the various methods? What are their advantages and disadvantages?

(3) How does the relative cost of testing by the various methods enter into the economics of the entire exploratory operation?

The cost of the individual formation evaluation services and the rig time they utilize is fairly well known and need not be discussed in detail. Ordinarily, the total cost of electric logs, dip meter surveys, sidewall samples, and core analysis including any rig time they involve, is only 2 to 5 per cent of the total cost of an exploratory operation. The greater part of formation evaluation cost is included in coring, formation testing, and mud logging.

In view of what might be considered a relatively low cost for electric logging, dip meter, sidewall samples, and core analysis; and, furthermore, in view of the importance of the decisions that are often made on the basis of these results, it would appear that a sufficiency of these less expensive methods should be employed. Consequently, it is desirable to core analyze rather completely any sand cores obtained from a formation that might represent a commercial reservoir in the well under consideration or at some other location. This is particularly true in view of the cost of coring. It would also appear economical to run the electric log at frequent intervals when nearing the objective horizons in a deep exploratory well. Lastly, despite the rather qualitative information obtained from sidewall samples, it is desirable to sample thoroughly any questionable horizons not well evaluated by the other techniques employed.

Acknowledgment

The conception of the need for a comprehensive review and analysis of exploratory drilling procedures is directly credited to J. E. Toussaint, manager, producing department, Standard Oil Company of California.

Much of the information constituting the nucleus of this analysis has been generously supplied by the exploration and the development personnel of the Standard Oil Company of California and other oil producing companies. To these persons, the author expresses his sincere appreciation and indebtedness.

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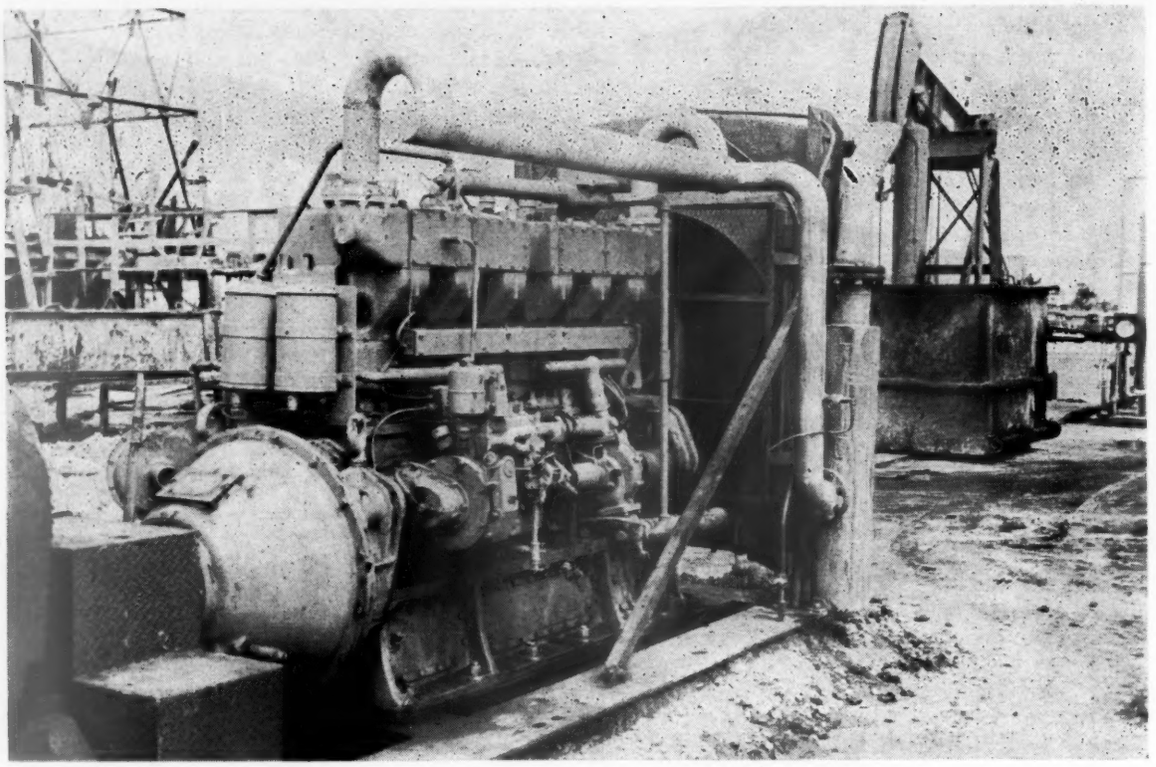

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Muffler Arrangement for Engines

J. C. ALBRIGHT

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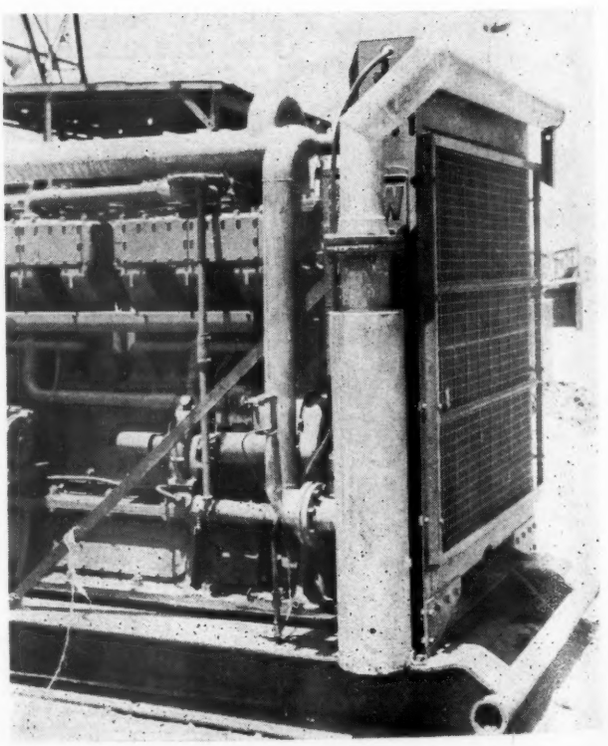

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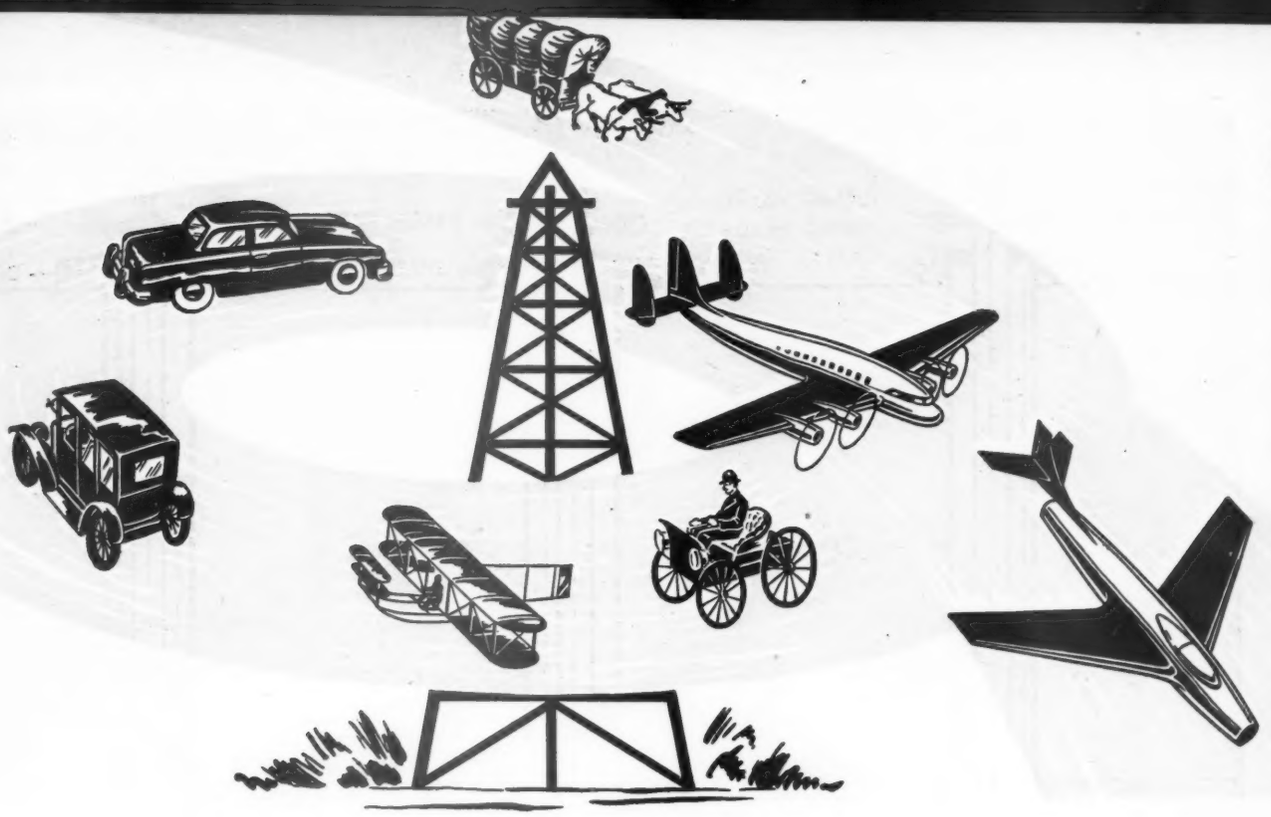

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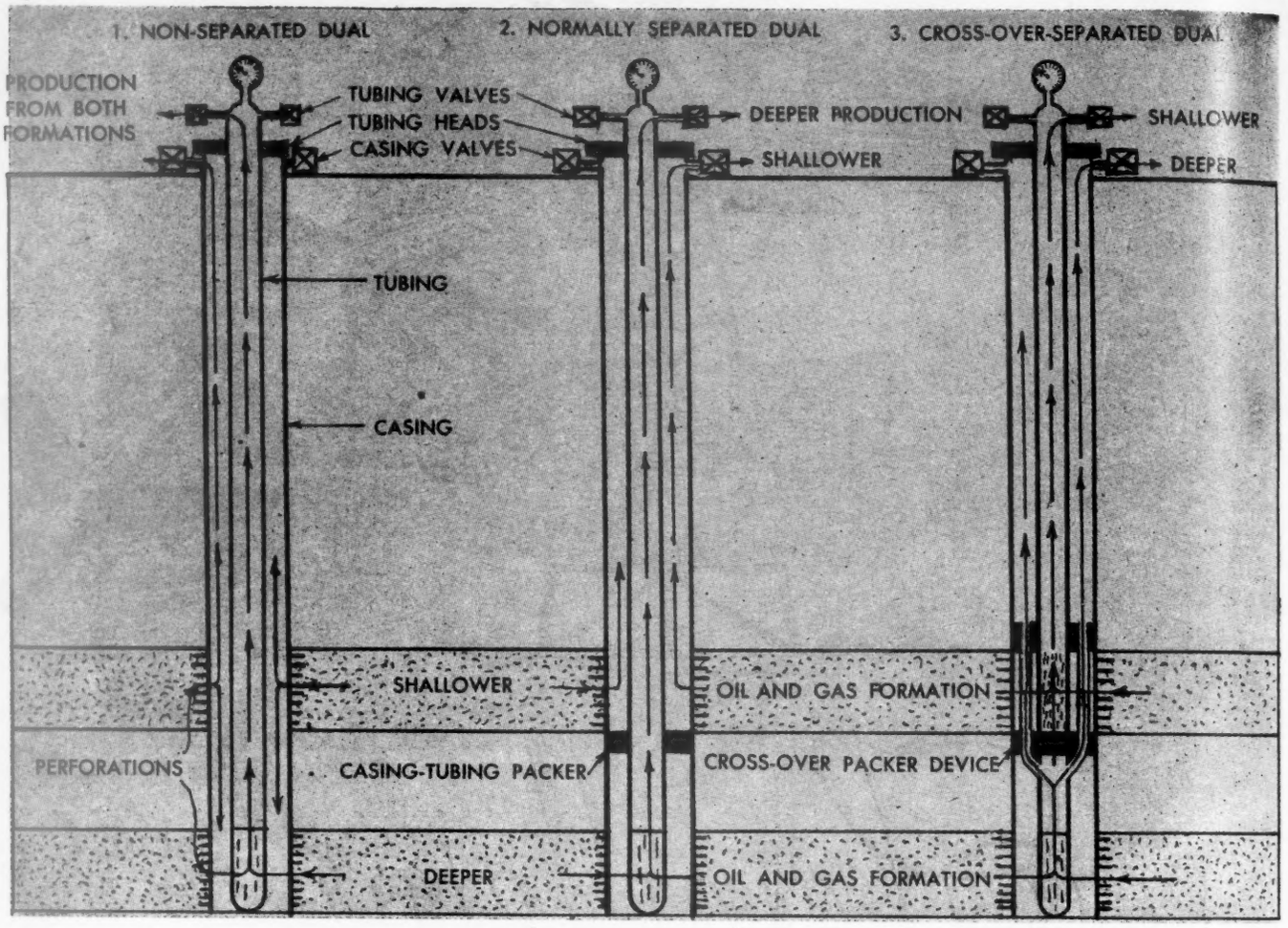

Schematic diagram of types of dual completions.

Well Completion Practices in Oklahoma

K. MARSHALL FAGIN*

THREE types of dual completions are being authorized by the Oklahoma Corporation Commission, which holds a hearing on all applications for permission to complete oil and gas wells from more than one producing formation. About 26 per cent of the applications are simply for permission to produce two formations through the same flow string and commingle the production in common tank batteries. This might be called a "non-separated" dual completion.

About 43 per cent of the applications are for permission to produce two formations through the same well bore, keeping the production separate by setting a packer between the tubing and casing, and producing the shallower formation through the annulus between the casing and tubing and producing the deeper formation through the tubing. Permission to make these "normally-separated" dual completions often includes permission to change over to the third type of dual completion whenever desirable.

The third type of dual completion provides for separation of the production from two producing formations and the use of a cross-over device that switches the flow from the deeper formation into the casing-tubing annulus and allows the shallower formation to produce directly and separately into the tubing. About 31 per cent of the applications are for this "cross-over" type of dual completion. It enables the producer to pump production from the shallower zone while flowing production from the deeper zone. Cross-over duals are usually made initially when operators anticipate that the shallower zone will have to be pumped long before the deeper zone reaches that stage of depletion. Normally-separated dual completions may be changed over, however, to the cross-over type of dual when the shallower formation quits flowing.

It is interesting to note from the accompanying table that permission has been granted to produce several rather deep formations together

*Editor, Drilling and Producing.

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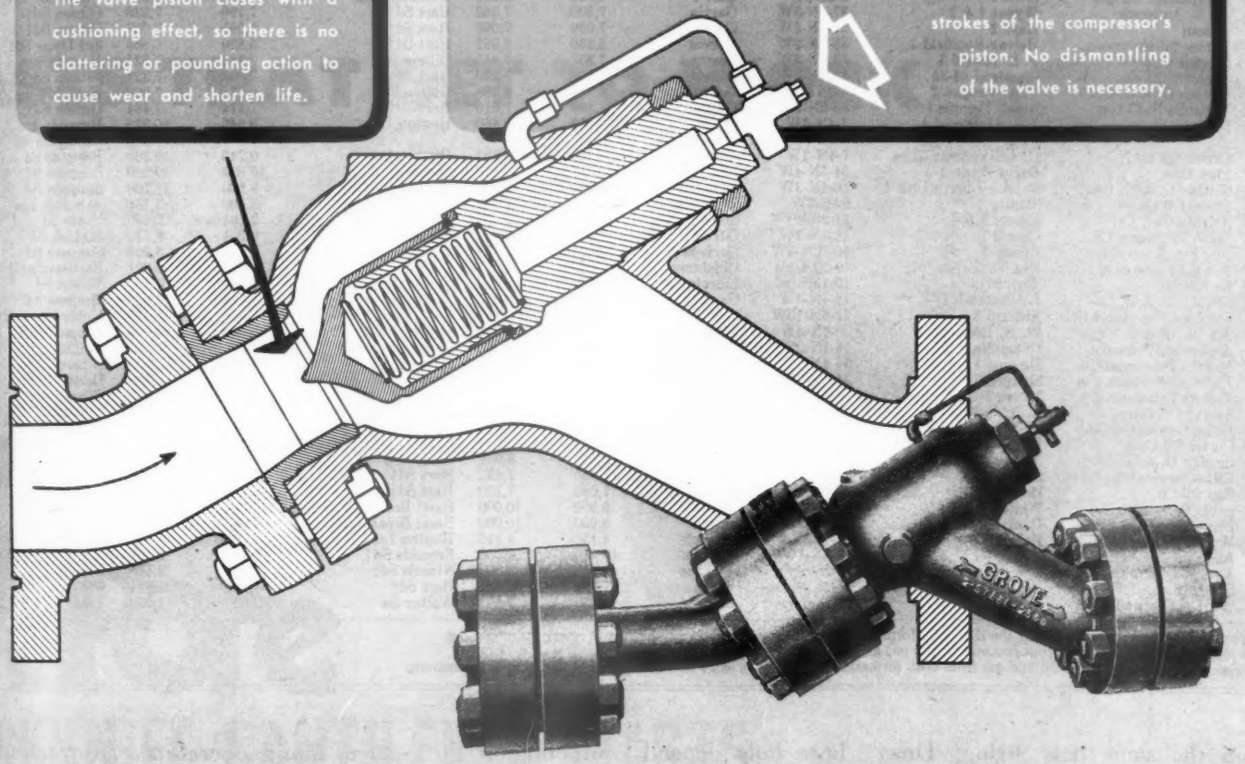

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24156	Sinclair O. & G. Co.	M. L. McLain "A" 1	27-2N-2W	Garvin	6,606	6,700	Gibson Sd°	6,766	6,778	Hart Sd
24289	Cities Service Oil Co.	Dunlap 2	10-12N-2W	Oklahoma	6,342	6,384	Hunton Lm†	6,234	6,240	Bartlesville Sd†
24194	Sinclair O. & G. Co.	G. W. Burris 13	27-2N-7E	Pontotoc	2,520	2,700	Cromwell Sd*	3,385	3,500	Hunton Lm*
24198	Sinclair O. & G. Co.	G. W. Burris 12	27-2N-7E	Pontotoc	2,495	2,645	Cromwell Sd*	3,372	3,483	Hunton Lm*
24200	Sohio Petroleum Co.	Howard "A" 1	17-1N-2W	Garvin	10,046	10,204	Basal Bromide Sd	10,700	10,805	McLish Sd
24264	Superior Oil Co.	Buckholts 53-23	23-3N-3W	Garvin	7,180	7,213	Hart Sd†	7,081	7,121	Gibson Sd†
24162	Kerr-McGee	City 1	27-2N-2W	Garvin	6,864	6,889	Hart Sd†	6,712	6,790	Gibson Sd†
24187	Anderson-Prichard	Savage Unit 1	27-5N-4W	McClain	10,010	10,100	Hunton Lm*	10,897	11,136	Bromide Sd*
24169	Superior Oil Co.	Olmstead-Norville 82-35	35-3N-3W	Garvin	7,408	7,428	Hart Sd†	7,247	7,270	Gibson Sd†
24128	Frank Buttram	Dunn 1-A	9-5N-2W	McClain	7,148	7,160	5th Deese Sd	7,248	7,255	Hunton Lm
24085	Carter Oil Co.	Vierson C-288 No. 1	26-3N-3W	Garvin	7,594	7,636	Hart Sd†	7,449	7,518	Gibson Sd†
24287	Sinclair O. & G. Co.	T. A. Vaughn 3	3-3N-3W	Garvin	6,830	6,890	Gibson Sd°	6,940	7,000	Hart Sd°
24148	A. W. Swift & Co.	Werhan 1	15-19N-10E	Tulsa	952	957	Layton Sd*	1,867	1,878	Red Fork Sd*
24068	Stanolind O. & G. Co.	Maxwell Unit 1	36-13N-3W	Oklahoma	6,321	6,368	Hunton Lm*	5,710	5,719	Cleveland Sd*
24281	Kirkpatrick Oil Co.	Scott 1	8-2S-3W	Carter	3,750	3,930	Fusilinid Zone*	4,000	4,310	Tussy Sd*
24324	W. E. Anderson	Wyant 1 & 2	27-4N-3W	Garvin	7,300	7,362	Hart Sd†	7,190	7,236	Gibson Sd†
24090	Amcan	Hays 2	27-4N-3W	Garvin	7,059	7,080	Hart Sd†	6,965	7,007	Gibson Sd†
24086	Carter Oil Co.	Helvey-Bonifield 1	35-2N-2W	Garvin	6,930	6,952	Hart Sd†	6,820	6,865	3rd Deese Sd†
24292	Sinclair O. & G. Co.	P. E. Harrill 1	33-4N-3W	Garvin	7,337	7,415	Gibson Sd°	7,486	7,521	Hart Sd°
24259	Superior Oil Co.	Olmstead 64-35	35-3N-3W	Garvin	7,480	7,520	Hart Sd†	7,308	7,328	Gibson Sd†
24104	Sinclair O. & G. Co.	T. A. Vaughn 2	3-3N-3W	Garvin	6,827	6,888	Gibson Sd°	6,938	7,000	Hart Sd°
24325	Republic Nat'l Gas	Burch Hemple 1	35-3N-3W	Garvin	7,596	7,616	Hart Sd†	7,414	7,434	Gibson Sd†
24043	Sinclair Oil Co.	I. L. McDaniel 1	7-4N-3W	Garvin	8,450	8,850	Hunton Lm	9,646	10,328	Bromide & McLish Sd
24078	Carter Oil Co.	C. A. Tilghman 2	7-4N-3W	Garvin	8,816	8,868	Hunton Lm	9,745	10,200	Bromide Sd
24284	Max Pray	Daisy Wynn 1	34-5N-4W	McClain	9,830	9,864	Hunton Lm	10,800	10,980	Simpson Sd
24108	Sinclair O. & G. Co.	Bullock-Cherry Unit 1	18-4N-3W	Garvin	8,700	9,150	Hunton Lm	9,500	11,200	Simpson Sd
24110	Eason Oil Co.	Stanley 1	8-2S-6W	Stephens	3,080	3,130	Yates Sd	3,300	3,340	Arbuckle Lm
24061	Atlantic Ref. Co.	Varner 3 & 4	21-2S-6W	Stephens	2,557	2,616	Nichols Sd	2,664	2,680	Yates Sd
24059	Sohio Petroleum Co.	Cassell 1	18-1N-2W	Garvin	9,400	9,600	Basal Bromide Sd	9,704	9,740	McLish Sd
24089	Bay Petroleum Co.	Brown 1	10-20N-4W	Garfield	5,084	5,104	Oswego Lm	5,815	5,906	Simpson Sd
24076	Powel Briscoe et al	Eva Taylor 1	12-12N-1W	Oklahoma	5,462	5,500	Cleveland Sd	6,080	6,091	Bartlesville Sd
24310	Ned Biffle	Way B-1	19-12N-6E	Lincoln	4,430	4,470	Misener-Hunton	4,683	4,687	Wilcox Sd
24316	Sinclair O. & G. Co.	J. Mantooth 1	14-4N-3W	Garvin	6,742	6,870	Deese Sd°	7,716	7,830	Simpson Sd°
24038	Stephens Petroleum Co.	Richard 2	27-6N-10W	Caddo	2,128	2,183	Fortuna Sd*	3,218	3,523	Noble Olson Sd*
24393	Sinclair O. & G. Co.	W. K. Donnell 14	20-4N-3W	Garvin	7,050	7,500	Deese Sd°	9,000	11,000	Simpson Sd°
24383	Anderson-Prichard	Crane-State 1	16-1N-2W	Garvin	9,940	10,090	Basal Bromide Sd	10,500	10,600	McLish Sd
24342	Vickers Petroleum Co.	Sheegog 1	34-4N-3W	Garvin	7,128	7,172	Hart Sd†	7,045	7,065	Gibson Sd†
24342	Vickers Petroleum Co.	Sheegog 2	34-4N-3W	Garvin	7,396	7,420	Hart Sd†	7,248	7,320	Gibson Sd†
24342	Vickers Petroleum Co.	Moore 1	34-4N-3W	Garvin	7,424	7,444	Hart Sd†	7,249	7,288	Gibson Sd†
24377	Sunray Oil Corp.	A. N. Harley B-7	28-2S-6W	Stephens	2,300	2,315	Moncrief Sd	2,664	2,674	Yates Sd
24376	Cities Service Oil Co.	Maledon 1	9-12N-2W	Oklahoma	5,610	5,656	Cleveland Sd*	6,261	6,281	Bartlesville Sd*
24349	Carter Oil Co.	R. E. Frankenberg 1	6-4N-3W	Garvin	8,520	8,574	Hunton Lm*	9,422	9,554	First Bromide Sd*
24348	Sinclair O. & G. Co.	Margaret Casker 2	27-4N-3W	Garvin	6,860	6,934	Gibson Sd°	6,983	7,005	Hart Sd°
24366	Cities Service Oil Co.	Harrill 1	33-4N-3W	Garvin	7,460	7,482	Hart Sd†	7,320	7,342	Gibson Sd†
24353	Sun Oil Co.	Helvey 1	2-1N-2W	Garvin	7,060	7,700	Hart Sd†	6,906	7,000	Gibson Sd†
24367	Sohio Petroleum Co.	Whitehead 1	18-1N-2W	Garvin	9,900	10,000	Basal Bromide Sd	10,500	10,600	McLish Sd
24367	Sohio Petroleum Co.	Dunlap 1	17-1N-2W	Garvin	9,900	10,000	Basal Bromide Sd	10,500	10,600	McLish Sd
24370	Winona Oil Co.	Heller 1	25-10W-7E	Seminole	4,130	4,215	Hunton Lm*	4,366	4,381	Wilcox Sd*
24384	Anderson-Prichard	McDaniel 1	34-5N-4W	McClain	10,730	10,900	Bromide Sd†	9,787	9,846	Hunton Lm.†
24382	Amerada Petroleum Corp.	Yates 1, 2, 3, 4 & 5	16-2S-6W	Stephens	2,540	2,560	Nichols Sd*	2,610	2,645	Yates Sd*
24352	Sun Oil Co.	Helvey-Parks 1	35-2N-2W	Garvin	7,024	7,074	Hart Sd†	6,856	6,944	Gibson Sd†
24379	W. H. Atkinson	Cassidy 4	21-2S-6W	Stephens	2,420	2,450	Walker Sd	2,630	2,650	Yates Sd

† A cross-over device is used to permit the shallower formation to produce through the tubing and prevent commingling.
° Flow may be crossed, if desired, but commingling is not allowed.
* Permission granted to produce oil and gas from both formations through the same flow string and to commingle production.

through the same flow string. This "non-separated" type of dual completion might result in the recovery of more oil by primary flowing and pumping methods than would be possible, if the formations were kept separate.

It is impossible, however, to measure separately the oil and gas production from each formation and thus determine how much each formation contributes to the total oil recovery. Separation of the production from two formations is desirable for measurement purposes as well as to prevent possible underground losses in oil recovery through equalizations of pressure between the two formations. In other instances, separation of the production from two formations is desirable due to significant differences in the gravity or type of petroleum produced from each. A gas-condensate producing formation, for example, is usually kept separate from an oil producing formation.

Whether or not it is good production practice to produce two formations into the same flow string or into separate flow strings in the same bore hole depends not only on the history of nearby producing operations from these formations but also on the kinds of fluids produced and the energy that causes the fluids to move into the well. In many instances, nearby wells have been completed in the two formations and produced simultaneously into the same flow string for a number of months, or even years, without any detrimental effects. The formations may have produced a similiar type of crude oil with moderate gas-oil ratios, no water, more or less equal bottomhole pressures, and similiar solution-gas drives. In such areas there is little reason to require that the production from the two formations be kept separate.

Should it be determined or suspected, however, that one of the formations has a different drive, a much different bottomhole pressure, a much different fluid content, or produces water, it is usually advisable to keep the two producing formations separate until further experience indicates that it is not necessary in the interest of good conservation practice. Many operators can recall the practice of completing a well in an oil producing formation and in a shallower gas producing formation solely for the purpose of getting a better flowing well. Such practice may produce more oil initially by flowing and pumping, however, as the gas formation pressure declines, considerable oil may be lost by migration into the gas producing formation.

This underground loss may be serious, particularly, if there is a gas cap and other operators produce the gas in large quantities. State regulatory bodies, such as the Oklahoma Corporation Commission, usually require operators to present all available data at a public hearing before permitting them to produce two formations together or separately through one bore hole. This enables the regulatory body, offset operators, and other interested persons to consider the merits of each case. Dual completions are then granted in accordance with the data on the formations and in the interest of good production practice.

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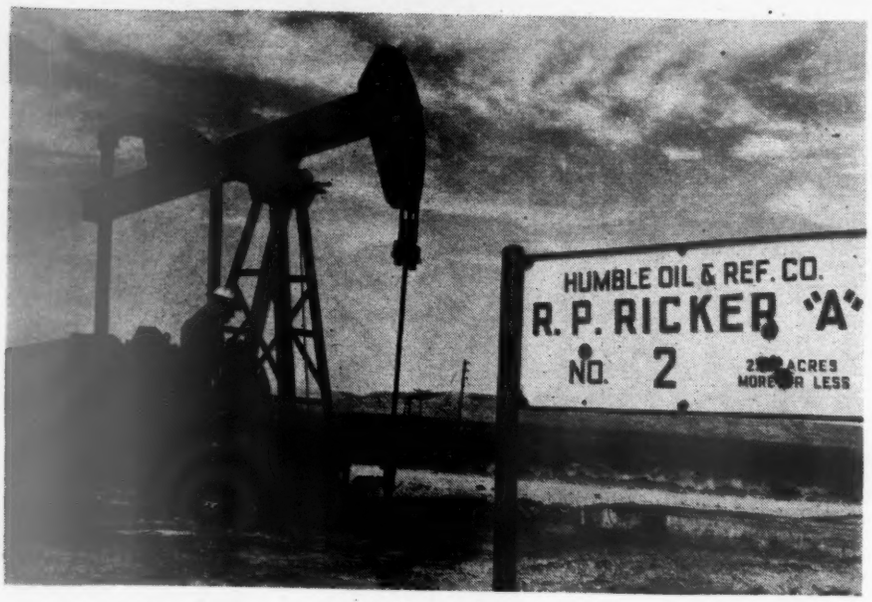


On R. P. Ricker No. 2 the new inhibitor will test a continuously pumping well.

A New Inhibitor for Sulfide Corrosion

J. A. CALDWELL*

CORROSION of tubing, rods, pump parts, wellhead fittings and flow lines of oil wells producing fluids containing hydrogen sulfide has long been a serious problem. In recent years this problem has been discussed by numerous investigators with the result that producers to an ever increasing extent are becoming aware of losses that in the final analysis should be charged to corrosion. It is likely that the true cost of corrosion in sulfide-producing wells is not yet fully realized, however, because detailed records of material failures are often lacking.

A careful analysis of costs on any particular well in a corrosive area may yield a surprisingly high figure to be charged against corrosion. For example, a well operated by Humble Oil and Refining Company in a sour crude area of West Texas was found to have had a total of 23 sucker rod failures attributable to corrosion during the period January 1, 1946, through June 30, 1947. The cost of replacing the broken rods and installing two strings of new rods was about $3000. In addition, there were during the same period 4 tubing failures, which cost $500. The daily average oil production from the well was less than 10 bbl; the total oil production was about 5000 bbl for the period of 18 months for which the figures are given. Comparison of the figure of $3500 with the market value of 5000 bbl of oil shows that a substantial percentage of the gross revenue was thus lost.

*Humble Oil and Refining Company.

Controlling Corrosion

The three most obvious ways of controlling corrosion in wells producing sulfide fluids are the use of protective coatings, alloy steels, and chemical inhibitors. Several plastic coatings are available, some of which have been used to advantage in both flowing and pumping wells. Alloy steels have been used successfully, principally for the sucker rods and pump parts; in many cases the higher cost of the material makes difficult the justification of its use. Chemical inhibitors have come into general use recently. These materials are usually employed for the "down-the-hole" treatment. The possibilities of substantially reducing at reasonable cost the corrosion now occurring in sour crude wells appear to be considerable.

A new inhibitor for sulfide corrosion in producing oil wells has been developed by Humble Oil and Refining Company and has been placed on the market under the trade name of "Corexit."

During the past several years Humble Oil and Refining Company has carried on an active research program on corrosion. Part of this research included laboratory testing of numerous available materials for their effectiveness as corrosion inhibitors, and from this effort there were developed new synthetic inhibitors. Consideration of price will at present prevent the use of a number of apparently effective chemicals, but the research has yielded several of reasonable cost that show considerable promise. In the experimental work the fact has been kept in mind that certain auxiliary properties are desired in a corrosion inhibitor for treatment of oil wells. Some of these are:

1. The inhibitor should be a free-flowing liquid or easily dissolved solid.
2. It should have no objectionable odor.
3. It should be non-toxic.
4. It should be available at reasonable cost.

Injecting Inhibitors

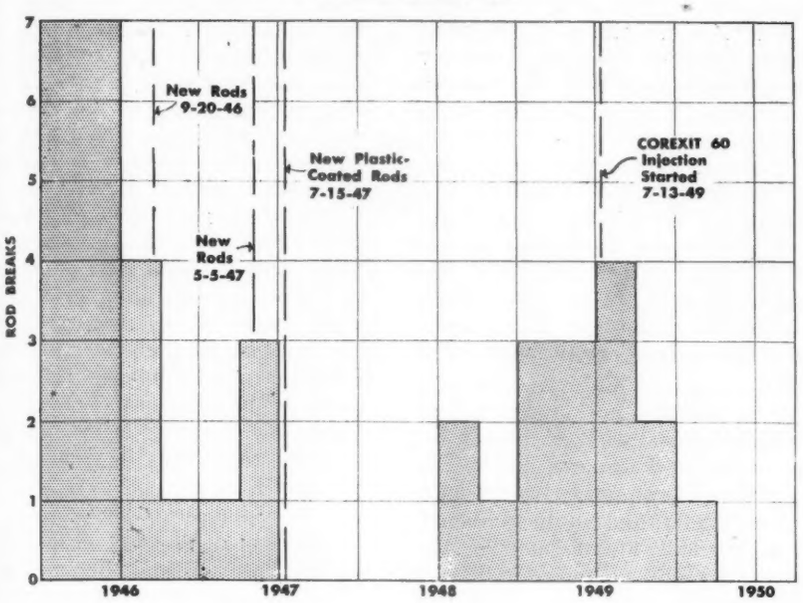
In conjunction with the laboratory research, field trials of various inhibitors have been under way for several years in sour crude areas of West Texas. The inhibitor is injected into the annulus between tubing and casing, so that it goes to the bottom of the well and travels up the tubing to the surface with the produced fluids. Chemical feeders operating from the walking beam of the well, and gravity-feed lubricators have been used to inject the chemical. An initial amount of the inhibitor, usually 5 gal, is batched into the annulus, and by a simple piping arrangement the inhibitor and well fluids are circulated for 24 hours in the closed system consisting of annulus and tubing. Continuous injection by means of a chemical feeder or daily batch injection by means of a gravity-feed lubricator is then begun.

Reduction of Corrosion

Corexit, the new corrosion inhibitor developed in the laboratory and now being manufactured by Humble Oil and Refining Company, has shown very encouraging results. This inhibitor is a non-toxic, free-flowing liquid, with very little odor. A test of Corexit was begun in W. R. Settles 11 and 12, Howard-Glasscock field, early in 1949. Each of these wells pumps continuously from a depth of about 2400 ft

EFFECT OF INHIBITOR INJECTION ON NUMBER OF ROD BREAKS

R. P. RICKER A-8 McCAMEY FIELD

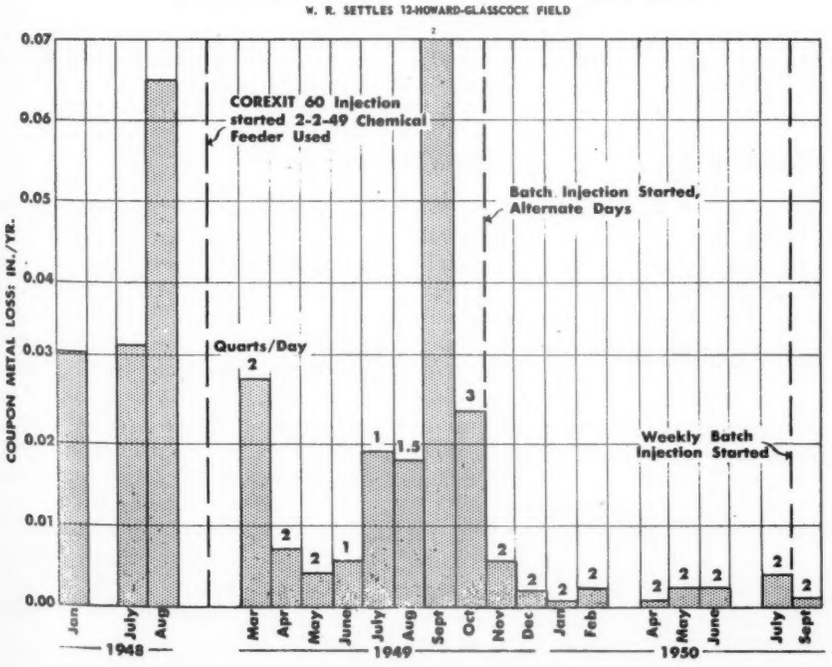


and produces about 30 bbl of oil and 30 bbl of water per day. Rod failures have been few, but tubing failures have been frequent. A string of tubing that consisted partly of 600 ft of plastic-coated pipe and partly of black pipe in good condition was installed in Settles 11 in January, 1948. When this string was pulled for inspection late in the year, it was found that many of the joints of both the coated and uncoated pipe were badly corroded and the mud anchor was completely penetrated. Injection of Corexit was started in Settles 11 in February, 1949. As of this writing, there have been no tubing leaks in this well resulting from corrosion since the start of the test. After the initial treatment the inhibitor was used in amount such that the daily cost of chemical ranged between $0.50 and $1.00.

A string of used tubing in good condition which had been newly plastic-coated was installed in Settles 12 in September, 1948. It was necessary to pull the tubing four times in the next 66 days because of failure of one or more joints, either by complete penetration of the pipe or failure at the threads. The coated string was removed and a string of new uncoated pipe was installed; another pulling job was necessary in about 2 months because one joint of tubing corroded through during the period. Treatment with Corexit was started in February, 1949, and was continued for 3 months

EFFECT OF INHIBITOR INJECTION ON CORROSION OF FLOW-LINE COUPONS

W. R. SETTLES 12-HOWARD-GLASSCOCK FIELD



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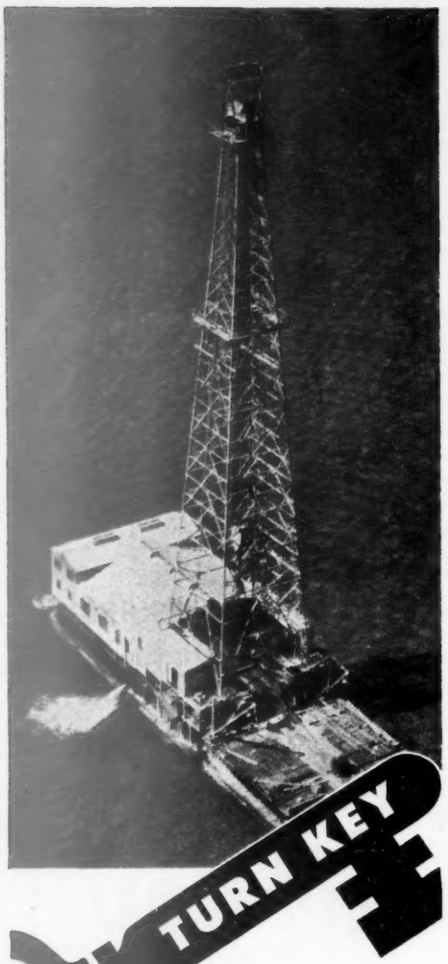

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at an average cost for material of $1.00 per day. There were no tubing failures during this period. In order to determine the minimum amount of inhibitor needed the daily treatment was reduced such that the material cost was $0.50 per day. Three tubing failures were then experienced, the first of which occurred in August, 1949, indicating that an insufficient quantity of the inhibitor was being used. The amount of inhibitor injected was increased in October, 1949, to a material cost of $1 per day. There have been 2 subsequent tubing leaks, one in March, and one in April, 1950.

Sililar tests of Corexit have been made in the McCamey field of West Texas. Treatment of R. P. Ricker A-2 was begun in February, 1949. This well pumps continuously from a depth of about 2200 ft and produces about 5 bbl of oil and 25 bbl of water per day. It is not a highly corrosive well when compared with some others in the McCamey field but it had 11 rod breaks in 1947 and 7 rod breaks in 1948 because of corrosion. Through April, 1950, when the test was temporarily discontinued, there had been 2 rod breaks since start of chemical injection; cost of treatment, except for the first month, was approximately $0.50 per day.

Injection of Corexit into R. P. Ricker A-8, McCamey field, was begun on July 13, 1949. This well pumps continuously from a depth of about 2200 ft and produces about 9 bbl of oil and 175 bbl of water per day. New plastic-coated rod and tubing strings were installed in this well in July, 1947, following difficulty in keeping the well on regular production because of frequent rod breaks. There were no rod breaks during the latter half of 1947 and first half of 1948. There were 3 rod breaks in the second half of 1948 and 9 rod breaks in the first 7 months of 1949, three of which occurred in July. Eleven of the 12 rod breaks are known to have occurred in the upper 975 ft of the string; the location of the remaining break is not known. When injection of Corexit was begun, no change was made in the rod string even though many of the rods were known to be deeply pitted. However, during an inspection on September 30, 1949, fourteen pitted rods (350 ft) at the bottom of the string were replaced with new rods. There have been 4 rod failures since start of injection of the inhibitor in July, 1949, one of which occurred on August 1, 1949, probably before the protective film of inhibitor was complete. There have been no breaks since February 21, 1950. The cost of the treatment has been approximately $1 per day.

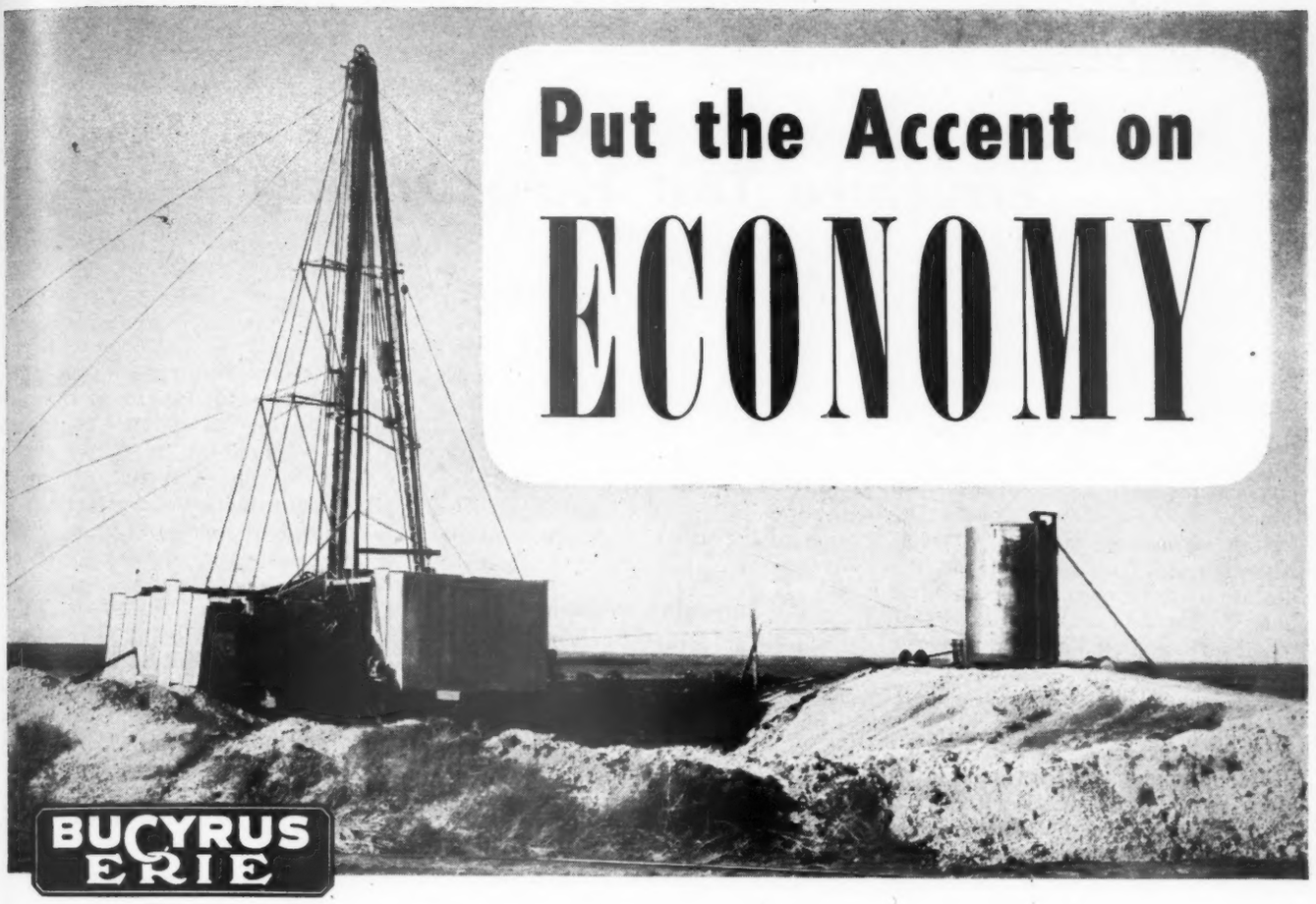
Cost of Inhibitors

It should be understood that chemical inhibitors cannot be expected to eliminate corrosion entirely and to give complete protection to steel in a corrosive environment. The tests with Corexit indicate, however, that under some conditions sufficient reduction of the rate of severity of corrosion may be obtained through use of inhibitors to warrant their use. Three of the 4 wells chosen for the tests described in this paper are highly corrosive and are located in areas where other operators have had similar difficulty in maintaining steady production. The expenditure of several dollars per day for a satisfactory method of reducing corrosion can be justified in such cases. It is likely that there are many moderately corrosive wells in other fields which can be satisfactorily treated at low cost with resultant net savings of several hundred dollars per well per year. It is conceivable that a few wells which would otherwise have to be shut in or abandoned because of material failures could, by the use of a suitable inhibitor, be profitably produced. * * *

Nickel-Plated Tubing For Gas Wells

In order to keep abreast of the increasing demand for petroleum products, the oil industry has had to rely on production from the "sour" oil wells. The presence of hydrogen sulfide along with carbon dioxide causes the sour crude oil to be very corrosive to oilwell tubing and requires some means of protection. This gives rise to a potential field of application for nickel, which is well suited for use in these corrosive media.

Over 30,000 lineal feet of 2 in. to 2½-in. tubing have been internally nickel plated for installation in distillate gas wells where these extreme corrosion conditions are encountered. These orders were placed on the basis of the excellent performance of sample lengths of the plated pipe which showed no effect of corrosion, after 18 months exposure, while a carbon steel pipe was severely corroded. One 10,000-ft length of plated tubing has been installed in a well several miles off shore in the Gulf. This tubing has been given a nickel deposit of 0.006-in. Plating is regulated so as to deposit over the outside threads on the ends of the pipe to protect them. The couplings are also plated internally, giving full protection to the surface in contact with the oil. — *Nickel Topics.*



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Central Alberta

Structure Test Hole Drilling

ARNOLD E. CAMPBELL

STRUCTURE test hole drilling has been employed rather extensively in Central Alberta to supplement surface and subsurface geological and geophysical methods, for correlation and delineation of subsurface strata in detection of possible oil and gas traps. Although, in common with all exploration techniques, structure test holes do not indicate a unique picture of subsurface anomalies, they do serve as a further aid to accurate interpretation, when used in conjunction with other related data. The general procedure entails drilling slim holes to a distinctive shallow formation, running electric logs to this horizon, and, from the electric logs, constructing a subsurface contour map on top of the designated formation to determine favorably anomalous structures.

Planning the Program

The first consideration in planning the proposed drilling program, assuming that the desired area of operations has been selected, involves estimation of the intensity of drilling required. This will depend upon the complexity of the structures and the accessibility of drilling locations. Where structures are relatively simple, six-mile spacing is usually adequate, and holes are consequently drilled on township corners; where structures are more complicated, one-mile or even one-half or one-quarter mile spacing may be necessary. In any event, a subsurface contour map is kept up-to-date while the program progresses, and spacing may be altered as desired to provide the required detail.

Permits Required

A blanket exploration permit for the area is acquired from the government to sanction drilling within the outer 10 ft of all government road allowances, which are 66 ft wide, allocated every 2 miles north and south from township corners on E-W lines, and every mile east and west on N-S lines. If the permissible 10-ft limits are inaccessible and locations must be moved within these limits or to private property, special permits from the government or the individual property owners, as the case may be, must be obtained, necessitating considerable expenditure of time and money. Therefore, whenever possible, the required holes are drilled on the road allowances, to expedite the completion of the program as economically as possible.

Surveying Problems

The exact location and elevation of the drilling sites must be determined accurately for subsequent correlation with the subsurface contour map and electric logs. Test holes are normally tied in to township and section corners, and elevations are referred to known geodetic bench marks, or similar known datum levels. The determination of township and section lines is facilitated in populated areas by cross roads, by fence lines and fence corners, and by township pins and section pins. In sparsely-settled areas or open country, where fence lines and corners are haphazard at best and roads are ill-defined or non-existent (despite the above-mentioned government road allowances), elevations and section lines must often be surveyed in for considerable distances with plane table, or transit and tape, to locate sectional divisions.

Although township and section corners were conspicuously marked during initial land surveys, in many instances marker pins or plates have been removed, buried, or obliterated beyond recognition. Identification of boundaries is consequently more complicated and time-consuming. Unmarked corners may somtimes be detected by the presence of four grass-filled depressions about two feet square, which were the original pits for an instrument setup during the land survey.

Transportation Problems

The extensive irrigation systems and widespread sloughs of Central Alberta impose an additional problem in transportation and accessibility. Large tracts are sometimes isolated and without practical means of entry for the relatively heavy drilling equipment, thus necessitating inconvenient and untimely alterations of the proposed drilling program. Under such adverse conditions, it is sometimes difficult for the surveyor or engineer to maintain the necessary location or two ahead of the drilling, especially if several rigs are operating concurrently and completing these shallow holes in one to three days.

Furthermore, under the usual drilling contracts, a contractor must be compensated for moving his rig more than five miles between locations; therefore, the allocation of drilling sites must be planned carefully, to completely fill in the structure pattern and yet minimize the distances of rig movements.

Depth of Test Holes

The structure test holes are drilled to the Milk River sandstone of Upper Cretaceous age, which is encountered at depths ranging from 800 to 1200 ft and which gives a distinctive response on both the self-potential and resistivity curves of the subsequent electric logs. The Milk River formation of Alberta corresponds to the well-known Eagle and Virgil sandstones of Montana and Wyoming.

Drilling Practices

Truck-mounted rotary drilling rigs* with power take-off from the truck motor are used for drilling. Operators use 2½ in. drill pipe and conventional 4¼ in. fish tail and roller bits. One or two bits usually suffice for a 1000-ft hole. Replaceable-blade bits have been used effectively in soft formations, but, they are not generally adapted to the variable drilling conditions encountered. Some difficulty has been experienced because of blades twisting loose in harder strata, necessitating troublesome fishing jobs or inconvenient drilling up or sidetracking operations.

Except in rare instances of lost circulation or shallow gas pockets, when additives such as bentonite, mica flakes, rice hulls, or barites may be required, the holes are drilled with water, which mixes with the native clays to comprise a suitable drilling fluid. The necessary water is hauled

*Such as the Failing "1500."

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The *S. S. Jahra* on her delivery trials.

Supertankers for Superservice

The *S. S. Jahra,* first of more than a score of 28,000-ton supertankers constructed by Bethlehem shipbuilding yards for private interests in the past two years, is an outstanding example of Bethlehem's ability to design and construct ships to meet the specific requirements of the individual operator or of an entire industry.

These vessels represent fulfillment of the petroleum industry's need for big, fast, highly-efficient carriers capable of transporting oil products to and from the far-flung corners of the globe on a low-cost basis.

Fully representative of American postwar shipbuilding skill and achievement, these supertankers can be expected to provide many years of high-standard and low-cost service for their operators, because they have all of the inherent characteristics which for almost half a century have distinguished every ship bearing the title, "Bethlehem-Built."

MAIN PARTICULARS OF THE S. S. JAHRA

Length, overall	624 ft. 9¾ in.
Length, between perpendiculars	595 ft. 0 in.
Breadth, molded	84 ft. 0 in.
Depth, molded	44 ft. 0 in.
Draft, molded	33 ft. 0 in.
Deadweight, tons	28,300
Cargo capacity, bbls.	240,400
Shaft horsepower, max.	13,750
Speed, fully loaded, about	16½ knots

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Baltimore Harbor	Beaumont, Texas
Los Angeles Harbor	San Francisco Harbor

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to the location by tank truck from nearby creeks or irrigation ditches. The normal drilling crew consists of 3 men, 1 driller and 2 roughnecks, with supervision exercised either by a tool pusher or senior driller.

Contract Provisions

Although straight day rates are stipulated in a few agreements, most of the drilling is contracted on a footage basis, plus a day rate for standby time while electro-logging, waiting on orders, or cementing. Some footage contracts specify an increased rate per foot below a certain depth, say 1000 ft, where penetration becomes much slower and more difficult than above this depth. In addition, there is the above-mentioned charge for rig movements in excess of 5 miles. The contractee is responsible for supplying the chemicals or other additives necessary for mud conditioning, at the few times when this treatment is required. If gas is encountered, the Petroleum and Natural Gas Conservation Board requires that the hole be cemented before abandonment, and the contractee is liable for this expense also, although, if he so desires, he may make use of the contractor's equipment and crews for the relatively simple cementing operations, rather than engage a cementing contractor.

Drilling Problems

Based on the available subsurface data from previous holes and surveys, the engineer or geologist in charge of the program determines the depths to drill, allowing a 15 or 20-ft margin for reaching the Milk River sand. Underestimation of the top of the sand, if not detected until after the hole is logged, results in the added cost of running back in the hole to drill deeper and relog the hole to the required depth. Overestimation presents a problem, because the Milk River sand is gas-bearing in the middle and lower sections. It is therefore undesirable to penetrate to these depths, because that would necessitate a cement job upon completion.

In the early stages of the program, when subsurface control may be inadequate, an alert and conscientious driller can aid immeasurably in determining the top of the sand by noting the abrupt change in drilling time and the appearance of the characteristic sand in the return mud stream. As the subsurface contour map expands and greater control is attained, however, drilling depths may be estimated to within a foot or two.

Electric Logging Practice

When the drill has penetrated 5 to 10 ft of the marker sand, the pipe is pulled, and the hole is electro-logged by the two-electrode method, one resistivity curve being sufficient for the required depth determination. An electric logging truck is maintained on 24-hr standby, to minimize the waiting time between completion and logging. If the electric log is satisfactory, the hole is plugged with a wooden post or cemented, if necessary, and the rig is dismantled in preparation for the move to a new location.

The field copy of the electric log is correlated with the tentative structure contour map and the contours are adjusted, if required, to conform to the depth determination. As apparent anomalies develop, additional holes may have to be drilled to delineate these anomalies more accurately; conversely, if the structures are simple and relatively well-defined, some of the previously-planned holes may be omitted. In any event, the end result of the completed program is a detailed subsurface picture that may warrant subsequent deeper drilling.

In conclusion, it must be borne in mind that, as with all exploration techniques, structure test hole drilling provides only limited data for confirming or condemning existing data regarding possible oil reservoirs. In the final analysis, the presence or absence of commercial oil deposits can be determined only by actually drilling and testing the formations in question. * * *

☆ ☆ ☆

GEIGER COUNTERS MAY FIND OIL

Experiments are being conducted in the use of Geiger and other radiation counters in the search for new oil pools. Instruments that measure the penetration of various rock formations by radioactive materials will help scientists determine the composition of the formation and make it possible to determine whether a porous formation contains oil or water, either fresh or salt. Exploration and measurement with radiation counters may indicate the efficiency of other methods now used to find oil reservoirs.

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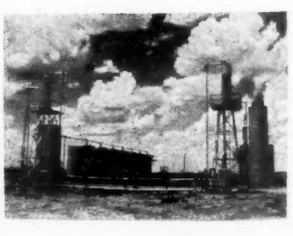

Wichita County, Texas

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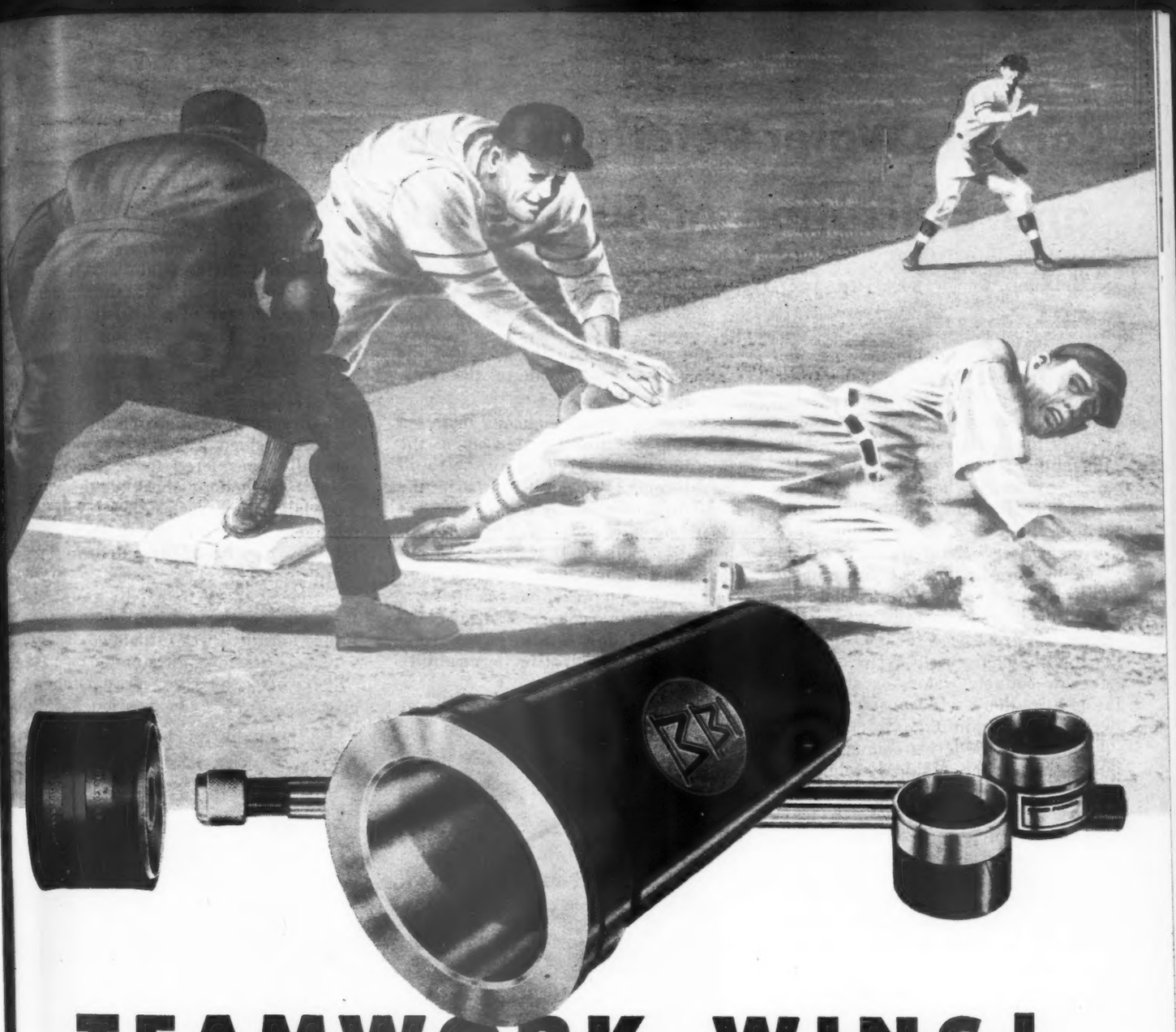

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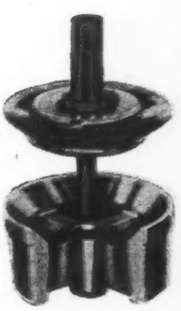

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Connate Water Determinations and Utilization of Such Data

E. J. SIMMONS*

A symposium on connate water and its importance to the petroleum industry was held recently by the Dallas Study Group of the North Texas section of the American Institute of Mining and Metallurgical Engineers. Dr. R. L. Slobod of the Atlantic Refining Company Research Laboratories led the discussion, which was concerned primarily with the definition and determination of connate water, and the utilization of connate water data.

While it was generally agreed that there is a great need for data that will enable the engineer to arrive at a figure for connate water for any given reservoir, there was considerable divergence of opinion as to the exact definition of the terms connate water. interstitial water, residual water, and irreducible water. Not only does this divergence exist within the petroleum engineering field, but also apparently among geologists. Whatever term is applied to the result of a laboratory test or series of tests, there must be a clear understanding on the part of everyone involved, from the laboratory technician making the tests on up to the reservoir engineer utilizing the data, of the entire scope and aim of the endeavor. The limitations of sampling, of method, of statistical analysis—all must be considered in evaluating the final result. The blind acceptance of a "percent connate water" or "average connate water" figure should be avoided.

The various laboratory methods of obtaining capillary pressure curves and from them the irreducible water saturation of core samples were discussed. The capillary disc method, with its inherent disadvantages, seems to be the most common method used in the industry. The consensus seemed to be that it is the basic method to rely upon. Other techniques, such as the centrifuge method (discussed in detail at a previous meeting) and the evaporation method have not yet been generally accepted throughout the industry.

The use of electric logs for the determination of connate water was discussed, and, although opinions varied widely as to the reliability of data so obtained, it was generally agreed that the most valuable feature of these determinations lies in the fact that the measurements are made on the reservoir itself.

An attempt was made to answer a question that was brought up at the previous meeting regarding the rapid establishment of equilibrium in the centrifuge method as opposed to the relatively slow attainment in the capillary disc method. It was pointed out that equilibrium can be reached more rapidly in a core in the centrifuge, because as the core desaturates, the direction of flow is always toward a zone of higher effective permeability to water.

The question of upper and lower limits of connate water percentages and their credibility was discussed briefly. Figures as low as 10 per cent and as high as 50 per cent have been generally acceptable, however, when the percentages go much lower or higher than these limits, the tendency is to doubt their reliability. It was pointed out in passing that the connate water percentage of a field in Chambers County, Texas, is reported to be in the range of 50 per cent to 60 per cent, yet pipe line oil is produced.

Correlation of laboratory results with direct water determinations made on cores drilled with oil base mud is generally considered to be the most reliable method of checking the various laboratory techniques. Only a relatively small amount of such correlation has been presented in the literature.

A questionnaire to help the program staff choose the subject matter for future meetings was circulated. These will be studied and announcements will be made later concerning future programs. * * *

AIME officers of the Kansas Section for 1951 are: Front row, J. C. Gallivan of J. A. Terteling and Sons, vice chairman for Western Kansas; L. D. Holsapple of Sinclair, vice chairman for Eastern Kansas, and G. L. Yates of Amstutz and Yates, chairman. Back row, G. J. Decker, Schlumberger Well Surveying, secretary-treasurer, and Tom Hamilton, National Cooperative Refinery Association, vice chairman for Wichita.

North Texas Section officers of AIME for 1951 include Earl C. Taylor, Jr., vice chairman for Wichita Falls; Gus Athanas, vice chairman for Fort Worth; Jack A. Crichton, chairman; K. Marshall Fagin, vice chairman for Dallas, and Kenneth F. Anderson, secretary-treasurer. Directors not shown are W. E. Stiles, Pat Reardon, R. G. Parker, Joab B. Harrell, Jr., and Gordon R. Stine.

*Sun Oil Co., Dallas, Texas.

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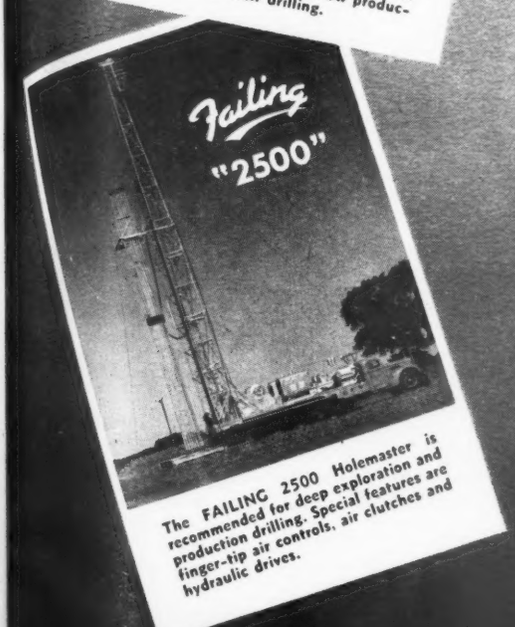

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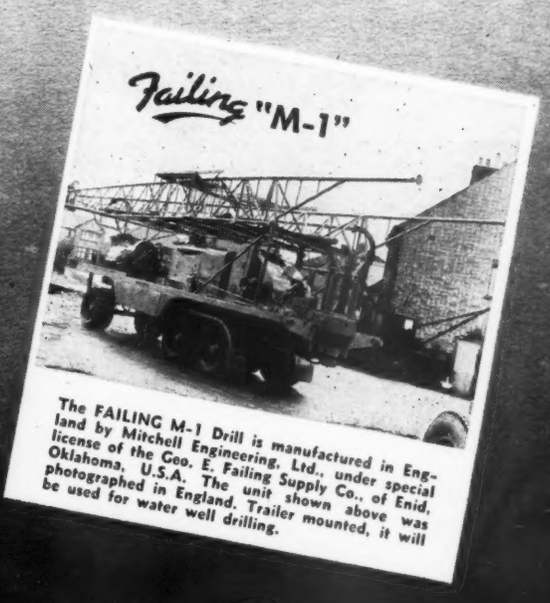

The FAILING M-1 Drill is manufactured in England by Mitchell Engineering, Ltd., under special license of the Geo. E. Failing Supply Co., of Enid, Oklahoma, U.S.A. The unit shown above was photographed in England. Trailer mounted, it will be used for water well drilling.

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NEWS

Georgia Offers Award For 250-Bbl a Day Well

Georgia reported that a total of four exploratory oil wells were drilled in 1950, all of which were completed as dry holes. H. A. Stallings, director of the oil and gas commission, reported that two wells were in Heard County, one in Seminole, and one in Decatur. Depths ranged from 1000 to 4195 ft.

Stallings also reported that the Georgia Oil and Gas Commission is receiving many inquiries about undeveloped acreage, and indications are that a larger number of exploratory wells will be drilled in 1951. Georgia is offering a cash award of $100,000 for its first commercial oil well producing 250 bbl a day or more, Stallings stated.

Crude Oil Output in Iran

Production of crude oil in Iran for the month of December, 1950, amounted to 2,945,000 long tons, according to Anglo-Iranian Oil Company, Ltd. Total production for the period January 1 to December 31, 1950 was 31,750,000 long tons, the company reported.

Venezuelan Output

Colon Development Company, Ltd., has reported its production in Venezuela for 4 weeks ending January 29 at a total of 389,790 bbl. This compared with 497,560 bbl produced during the 5 weeks ending January 1, 1951.

Wildcat Committee Named

Henry Salvatori, president of Western Geophysical Company of America, is the 1951 chairman of the Wildcat Committee of Western Oil and Gas Association. This committee, first formed in 1925, has been responsible for the annual oil men's High Jinks and Christmas play, which has been staged in the Biltmore Bowl for many years and through this show has been enabled to make substantial contribution to wartime rehabilitation efforts, as well as to the Red Cross and other worthwhile charities. Other officers named were Maurice A. Machris, executive vice president of Wilshire Oil Company, vice chairman; S. Z. Natcher, assistant to the vice president (conservation) Standard Oil Company, treasurer, and D. S. Kilgour, secretary of Western Oil & Gas Association, continues as secretary of the Committee.

Aubert Heads Petroleum Production Pioneers

At the annual meeting of the directors of Petroleum Production Pioneers, Inc., held in Los Angeles January 29, the following were elected to office for the current year: Honorary president, R. A. Broomfield, retired executive of Barnsdall Oil Company; honorary vice president, A. E. Fowks, retired Union Oil Company executive; president, L. L. Aubert, Bankline and Norwalk Companies; vice president, Fritz Huntzinger, Ventura Tool Company; treasurer, Paul E. Terry, The Capital Company; secretary, Richard Sneddon, The Petroleum Engineer; sergeant-at-arms, B. H. Anderson, Continental Oil Company; historian, Paul Andrews, Signal Oil and Gas Company.

As his last official act, S. F. Bowlby, the outgoing president, presented scrolls to R. E. Stearns and Glenn C. Merkley, honorary president and vice president respectively in his administration. In turn, he himself was the recipient of a gavel from the officers and members of the organization in recognition of his services as president during 1950. This presentation was made by President-Elect Aubert.

At right are past and present officers of the Petroleum Production Pioneers: L. L. Aubert, new president; R. A. Broomfield, honorary president; R. E. Stearns, outgoing honorary president; and S. F. Bowlby, past president.

S. F. Bowlby, past president of the Petroleum Production Pioneers, received a gavel from the officers and members of the organization in recognition of his services during the year 1950. In the picture are C. S. Penfield, committee chairman; Bowlby; L. L. Aubert, newly elected president, and Glenn C. Merkley, honorary vice president during 1950.

Shell Stops Search For Oil in Australia

The Shell Oil Company, which has spent more than $2,250,000 in an unsuccessful search for oil in the state of Queensland, is abandoning what until recently seemed a most promising field. It has called off test drilling at Rolleston, because according to drillers, it ran into a type of rock there which the company said "precludes the accumulation of oil."

1951 Rinehart Yearbook Reports Oil Discoveries

Exploration in the Texas-Mid-Continent area, the Rocky Mountains, and the Southeastern States resulted in 1477 oil and gas discoveries and major extensions during 1950, the Rinehart Oil News Company has reported. The wells are covered in detail in "Ira Rinehart's 1951 Yearbook", now off the press. The two-volume publication, including 88 maps, is a roundup of exploratory work between January 1 and December 31, 1950, in 23 states covered by Ira Rinehart's Oil Reports.

Included in the 1477 total are new oil and gas field discoveries, openers of new producing formations in previously established oil and gas areas, and major extensions to previous production.

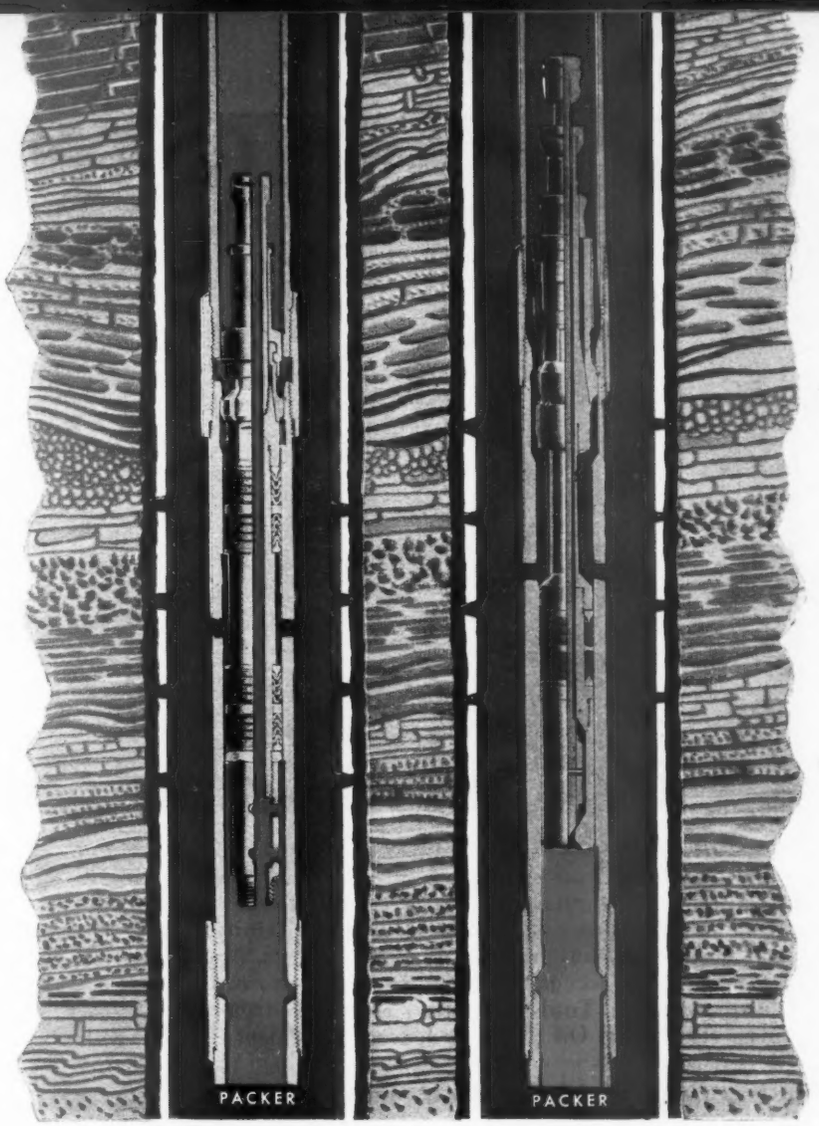
The following table divides the wells between completions and discoveries:

States	Total Completions	Total Discoveries
Alabama	46	3
Arkansas	1417	14
Colorado	90	12
Kansas	4135	90
Louisiana	2430	82
Mississippi	184	15
Montana	278	5
Nebraska	108	9
New Mexico	478	39
Texas	16,509	962
Utah	23	1

Also included in the 1951 yearbook are details on important wildcat failures in states that added no discoveries during the year, and drilling and production tables for the various states.

Saudi Arabian Output Lower in January

Crude oil production in Saudi Arabia during January amounted to 17,397,239 bbl, or an average of 561,201 bbl per calendar day, it was announced by the Arabian American Oil Company. This compared with 19,154,039 bbl or a daily average of 617,872 bbl per calendar day produced in December, 1950.



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More than 20 two-zone completion and production operations are practicable and economical with these basic tools and supplementary Otis Sub-Surface Controls. For example, an Otis Removable Side-Door Choke *(left)*, run in on a wire line under pressure and seated in a Landing Nipple made up in the tubing above the packer separating the two formations, allows the lower zone *(red)* to flow through the tubing, and the upper formation *(blue)* to be produced through the casing. An Otis Removable Separation Tool, *right*, blanks off the lower pay so that the upper zone, admitted through ports in the Nipple, can be produced through the tubing, or to allow acidizing operations, etc., for the upper zone only. Ask an Otis engineer near you for illustrated literature and details on these and the other Otis two-zone production tools. Otis Pressure Control, Inc., Box 7206, TWX DL-220, Dallas.

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Otis—outstanding in the Industry for pressure control

Houston Nomads Install 1951 Officers

The Houston, Texas chapter of Nomads held its annual dinner dance at the Shamrock Hotel recently, during which officers for 1951 were installed. Jack Barnes of Trinity Portland Cement Company was master of ceremonies. New officers shown in the accompanying photo are, front row: E. F. Baldwin, Hughes Tool Company, secretary-treasurer; Wayne Rives, The Oil and Gas Journal, president; E. R. Lorhen, Cameron Iron Works, regent; Jay Speece, Gardner Denver Company, deputy sergeant-at-arms; and, back row: Tracy Word, Jr., Well Equipment Manufacturing Company, regent; Herschel Wood, Lebanan Steel Foundry, vice president; Larry Kelley, Hillman Kelley Company, assistant secretary-treasurer; Bob Franklin, Rolo Manufacturing Company, sergeant-at-arms; and Harry Estes, A-1 Bit and Tool Company, executive secretary.

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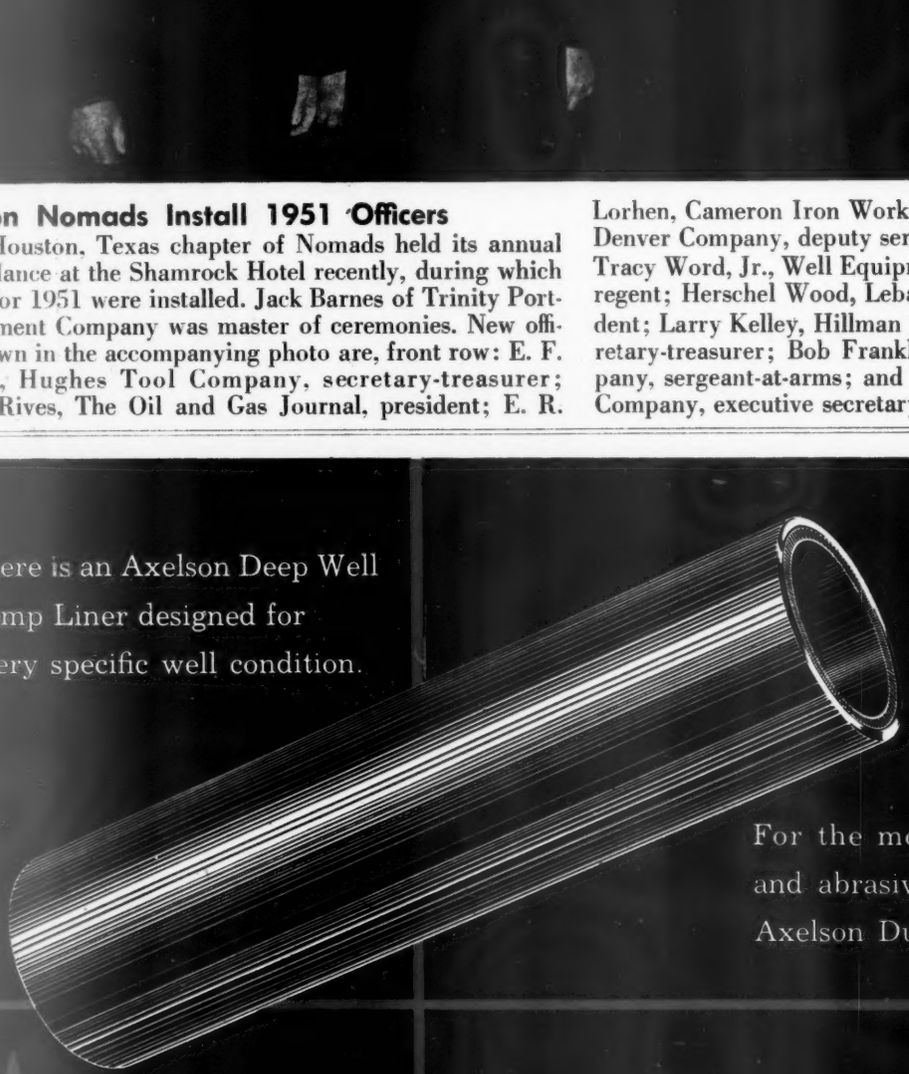

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AAODC Training Program Shows Progress

Seeking positive and effective means of reducing accidents, eliminating waste, minimizing cost, and hence increasing profit to the drilling contractor, the American Association of Oilwell Drilling Contractors became interested about two and a half years ago in a specialized training program for toolpushers and drilling crews. The Association at that time chose John Woodruff, coordinator of petroleum training in the extension division of the University of Texas, to cooperate in the formulation of an educational plan, designed specifically for the oil well drilling, and associated or related industries.

As a result, a two-part program was soon instituted, one part aimed particularly at management development and the other devoted to the training of rig crews. The management development course includes such important executive responsibilities as planning, organization, coordination, control, and direction. Understanding of these administrative phases of the total operation is expanded by personal interviews with head field representatives of AAODC member companies, such as the general superintendent of operations, his assistants, and the toolpusher. Discussion conferences with management groups, including superintendents and toolpushers, are also held.

The training of the crews is accomplished by holding meetings right on the rig with the driller or head well puller and their respective crews. The subjects discussed at these meetings are pertinent to the work of the field crews and each subject is allotted from 45 min to 1½ hr. They include such matters as safety and the safety check sheet; the cost, care, and use of hand tools; good housekeeping; operating the cathead and cathead lines; care of motors; fishing; making up drill collars; care and proper use of wire lines; correct operation of tongs; drill stem tests; swivel maintenance; preparation of well records and logs; the use of muds and caustic; the how and why of blowout preventers; and all the important operations and equipment with which the crews should be familiar to do the best for themselves as well as for their employees.

It is noteworthy that many of the oil well drilling contractors who participated in the initial two-year trial program have felt richly rewarded for the time and effort expended. They report substantial reduction in accident frequency and severity. Two companies have actually experienced a 50 per cent improvement in safety

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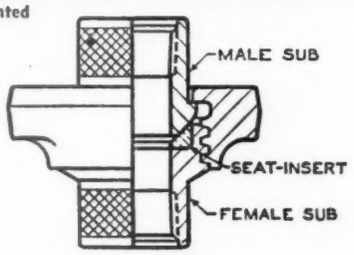

The replaceable bronze seat insert in the female sub assures a surface unimpaired by rust on lines involving condensation.

With the advent of the Weco Fig. 600 Union twelve years ago operators had, for the first time, a 6000 p.s.i. test union with wing nut and the new, fast Weco "Dizzy" thread, PLUS the bonus feature of a replaceable bronze seat. The basic design of this strong, tough union has met every test of toughest oil industry service . . . withstood every challenge to its leadership in fast make-up, easy break out, strength and extra long life.

Many operators have standardized on Weco Fig. 600 because the replaceable bronze seat prolongs its use far beyond the normal service life of ordinary unions . . . because it is available in sizes 1" through 4" with all parts interchangeable . . . because it is ideal for BOILER HOOK-UPS — BLOWOUT PREVENTER LINES—MUD LINES—STAND PIPE CONNECTIONS — BOILER HEADERS—HIGH PRESSURE SEPARATOR LINES.

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Join 'em right — the Victaulic way — and you'll be sure of easy, quick hook-ups. Pipe ends are joined by a simple two-bolt coupling. A speed or T-wrench is the only tool required. AND Victaulic Couplings keep 'em tight ... pipe joints stay positive-locked, leak-proof. Victaulic Couplings are designed to stand up under extreme pressure, vacuum, or strain conditions.

Preparing those pipe ends is a cinch the Victaulic way..."Vic-Groover" grooves 'em automatically in a jiffy, more than twice as fast as a conventional pipe threader!

SAVE time, work, and dollars on your piping construction and maintenance. JOIN UP with Victaulic.

Make your next piping job ALL VICTAULIC. Write today for Victaulic Catalog and Engineering Manual No. 44-8G.

NOTE VIC'S NEW COMBINED MAIN OFFICE AND PLANT ADDRESS BELOW—

Sizes—¾" through 60"

VICTAULIC COMPANY OF AMERICA
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Victaulic Company of Canada, Ltd., 406 Hopewell Ave., Toronto10
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27TH VICTAULIC YEAR

The easiest way to make ends meet
VICTAULIC
PIPE COUPLINGS AND FITTINGS

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effectiveness since the training program began, and there are many evidences of the fact that a well organized and carefully planned training program pays off in tangible benefits to those participating members who apply themselves seriously to the procedures and processes as outlined.

With the completion of the trial peroid and the evaluation of the results obtained, two progressive companies have been sufficiently impressed to adopt a unitized program and to conduct joint training operations under the Association-sponsored plan. These companies, California Production Service, Inc., and Brown Drilling Company, both of Long Beach, California, have only had the joint program under way since January 2, 1951; however, they are already favorably impressed with the results. Most noticeable, it is remarked, are increased enthusiasm on the part of toolpushers and supervisors for the training objectives; the use of check sheets on work jobs by toolpushers; and the use of safety check sheets alternately by crew members. It is sometimes difficult on short-term experience to lay one's finger on the exact dollars and cents saving that accrues from a safe, sane, logical administration and operation, however, the actual saving in hard cash is ordinarily high and easy to compute in time. The saving in heartaches is perhaps less capable of measurement but its beneficial effects are too well recognized to need any exposition here.

South Texas Group Given Safety Award

In recognition of an outstanding record of no lost-time injuries in five years of operation, employees of the Winnie area, South Texas division of the producing department of The Texas Company, were honored at a safety award dinner at Beaumont on January 31.

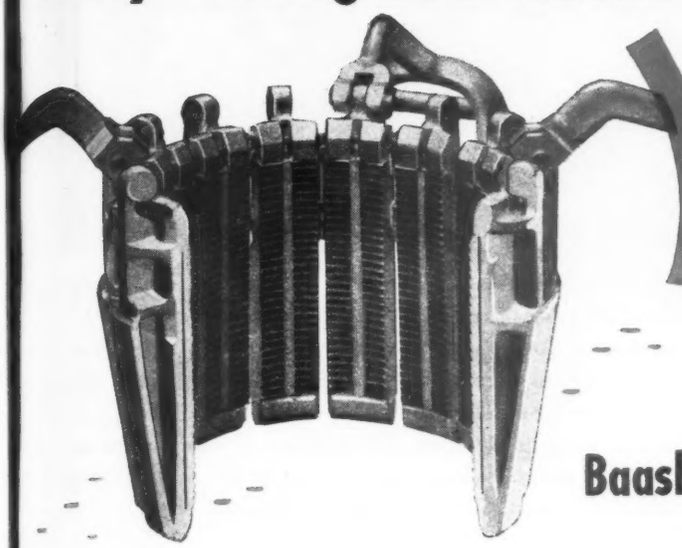
The dinner was attended by employees and their wives as well as company officials. A green and white safety award pennant was presented to the employees for working from December 12, 1945, through December 12, 1950, without a lost-time injury. W. H. Drushell, district superintendent, East Texas, made the presentation to Carl Krebs, production foreman at Winnie. L. J. Whetsell, assistant to the general manager of the producing department, gave the principal address. E. E. Callaway, assistant division supervisor of industrial relations, was master of ceremonies. Other officials from the Houston division office, including O. H. Hillyer, Jr., division supervisor of industrial relations, attended the dinner.

Baash-Ross News

BAASH-ROSS TOOL COMPANY • LOS ANGELES • HOUSTON • OKLAHOMA CITY • NEW YORK

OUR 31st YEAR

Every Casing Job Needs This Vital Protection . . .



Slips Specially Designed to safeguard thin-walled casing strings against crimping or other damage!

Baash-Ross Type "UC" Casing Slips

BECAUSE A STRING of casing has a relatively thin wall in relation to its diameter, it is much more easily damaged by unequal slip pressure than are drill pipe or tubing. Yet the weight of a string of casing—particularly under modern deep-hole drilling operations—can be extremely great . . . *so great, in fact, that even a slight misalignment of the slips or a moderate concentration of slip pressure can cause serious damage to the casing and might even result in losing the casing string down the hole.*

But such risks are now minimized through development by Baash-Ross of a new type of casing slip—the Baash-Ross Type "UC" Casing Slip. The Type "UC" Casing Slip consists of multiple segments, flexibly linked together so that they *w-r-a-p* around the casing like a chain tong to fit the exact curvature of the casing. Each individual slip segment takes the *same* uniform grip on the surface of the casing because *all* of the segments are unitized together—*act* as a unit, *set* as a unit, *grip* as a unit. This assures uniform slip pressure around the full circumference of the casing, eliminating risk of concentrated pressures that crimp the pipe and egg-shape the casing.

THREE BASIC BODY SIZES HANDLE WIDE RANGE OF CASING DIAMETERS

And here's an important point . . . Only *three* basic body sizes of "UC" Casing Slips are needed to handle *all* popular casing sizes from 7⅝" through 13⅜". As shown in the accompanying table, interchangeable liners are available for each of the three basic body sizes so that each size can be readily adapted to fit different casing sizes within its operating range . . .

Basic Body Size "UC" Casing Slips	13⅜"	10¾"	9"*
Interchangeable liners available to fit	13⅜"	10¾"	9"
	11¾"	9⅝"	8⅝"
			7⅝"

**Fits bore and taper of standard rotary table.*

LINERS EASILY REPLACED

The liners in "UC" Casing Slips have ample length and are so designed that they will cut through pipe scale and any surface coating on the casing to take a firm, slip-proof grip *without damaging the surface of the casing itself.*

And if at any time after long usage, the liners become dull—or when changing from one casing size to another as outlined above—they can be quickly and inexpensively replaced. Simply pull a stainless steel pin, replace the old liner with a new one, slide the pin back in place and the job is done. The stainless steel pins eliminate risk of corrosion and assure easy liner replacements. Furthermore, it is important to note that none of the load of supporting the casing string is placed on retaining pins, bolts or any other parts that can become sheared or lost in the hole. *For maximum safety and strength all weight on the liners is transferred directly to the Slip body itself!*

HERE IS WHY *every casing job needs the protection of Baash-Ross "UC" Casing Slips!*

Because casing has a thin wall in relation to its diameter, it is easily crimped or damaged by even small misalignments that would not affect thicker-walled drill pipe or tubing.

If casing diameters vary slightly or if the slips are not set at exactly the same level, conventional rigid-type slips cause concentrated slip pressure that can crimp, bottle-neck or squeeze the casing out-of-round.

Such damage not only risks dropping the casing string, but the bulged or egg-shaped areas can cause poor joint make-up as well as tight spots through which tools cannot pass. Moreover, wear concentrated on the bulged spot leads to premature casing failures.

The flexible unitized design of Baash-Ross Type "UC" Casing Slips eliminates risk of one portion setting higher or lower than the other . . . and the multiple narrow segments assure an accurate, safe grip that exactly fits the curvature of the casing.

RESULT—there is no concentrated slip pressure—no misalignment of slip segments—no risk of damaging the thin walls of even the longest and heaviest casing strings!

Type "UC" Casing Slips are light, compact and easy for the crew to handle on even the longest and heaviest casing jobs. And they are so inexpensive that every casing job you run can have the protection of this new slip advancement. Your nearest Baash-Ross representative will be glad to supply full details . . . or write direct

It Pays to Use...

Strata-Crete
TRADE MARK

...an aggregate to lighten your cement slurries

More and more oil men are discovering that cement slurries made with Strata-Crete give them these four valuable benefits — at low cost.

1. Strata-Crete substantially lightens the cement slurry.
2. With Strata-Crete, higher columns of cement can be pumped with lower pressures.
3. Strata-Crete with cement facilitates perforation.
4. Strata-Crete helps materially to reduce lost circulation of cement.

Strata-Crete is used with high early, slow set, or standard oil well cement. It is available through leading oil well cementing concerns.

Strata-Seal
TRADE MARK

to combat lost circulation of drilling mud

Recently made available to the oil industry, Strata-Seal has already proved to be one of the most highly effective, *practical* developments to combat lost circulation and returns.

So effective is Strata-Seal's bridging action, that even in a number of extreme cases, it has restored circulation and saved abandonment of wells.

Check these advantages

1. Strata-Seal protects investments by making possible reclamation of wells about to be abandoned.
2. Eliminates or reduces rig down time.
3. Savings resulting from ability to screen.
4. Has no detrimental effect on viscosity, water content and gel strength of drilling fluid.
5. Is easily added to mud.
6. Does not interfere with coring operations.

Available through leading mud service companies.

Sales Offices in Principal Oil Centers

SEND FOR SAMPLE VIALS
NO OBLIGATION

Feel the lightweight.
See the uniformity.

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Please send sample vial and technical data on

☐ Strata-Crete ☐ Strata-Seal

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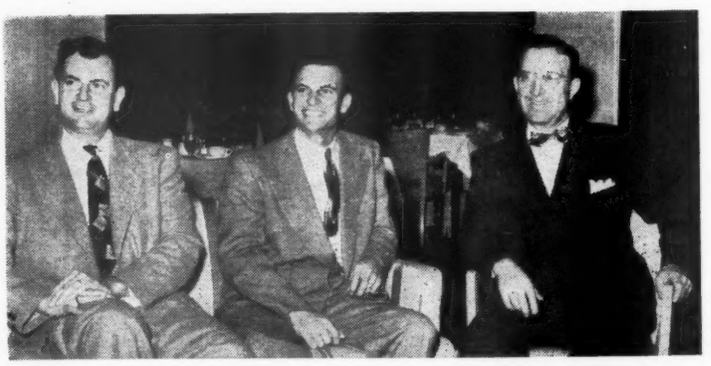
ADDRESS.....

.....

New officers of the Dallas-Fort Worth Chapter of Nomads are: Seated, Rollo E. Davidson of Associated Publishers, Inc., assistant treasurer; M. W. Hiltpold, Buda Company, assistant secretary; J. A. Mussler, Continental Supply, vice president; E. F. Shiels, International Derrick and Equipment Company, secretary; standing, Courtney J. Berlin, Baker Oil Tools, president; K. Marshall Fagin, The Petroleum Engineer, deputy sergeant-at-arms. Officers not in the picture are: J. E. Everroad, Mid-Continent Supply, treasurer; Vic Le May, Mid-Continent Supply, sergeant-at-arms; A. J. Olson of Continental Supply, regent; J. C. Baseheart, Buda Company, regent.



Guests at Nomads meeting in February were Walter T. Leseman, Hydril Company, who is opening Dallas offices in the Interurban Building, Larry Lee of D. D. Feldman Oil Company, a guest, and Earl M. Daniels, vice president of Hydril Company, and a member of Los Angeles Nomads.

H. J. Struth, petroleum consultant of Dallas, and Dr. Sultan Popol of Afghanistan were guests at a recent meeting of the Dallas-Fort Worth Chapter. Struth is retained by the Venezuelan government. Dr. Popol is studying petroleum exploration practices in the U. S. under auspices of the Department of State.

6 reasons why BLACK MAGIC is the only oil base drilling fluid you should use

It is generally conceded today that oil base muds are superior to water base muds for drilling into the producing zone. Permanent damage to the oil formation by waterblocking (Jamin action), mudding off or swelling of clay particles caused by water filtrate, has been eliminated by the use of a good oil base mud. Greater production for the entire life of the well has been the rule.

But not all oil base muds are alike. They differ in their composition and especially in the scope of their performance. Black Magic was the first successful oil base mud to be commercially available. It has had the advantage of nine years of continuous service and has set the pattern for others to follow. Only Black Magic meets all of these 6 requirements. We urge you to perform your own tests whenever possible under actual well temperature conditions and not be misled by claims that are unsubstantiated.

1 No harmful filtrates

Black Magic contains no water as such and under normal conditions can easily be maintained with a zero fluid loss. Black Magic can pick up as much as 25% water (by volume) during drilling, and still not squeeze any water into the producing formation. Black Magic will never be guilty of blocking production.

2 Excellent plastering properties

Black Magic possesses near-perfect plastering properties. It deposits a thin mud cake (1/64" approx.) which disintegrates in crude oil when the well comes on production, thus preventing any possibility of mudding off the pores of the oil zone. Holes are drilled "to gauge," too.

3 Highest return permeabilities

In every unbiased test performed on cores, Black Magic shows a greater return permeability than any other drilling mud available, sometimes recovery is as high as 96%. These experiments confirm what many operators have learned from actual drilling experience.

4 Greater flexibility

Black Magic is easy to maintain and can be weighted up to 21.4 lbs./gal. (160 lbs./cu. ft.) by adding ordinary commercial barites. It can be made lighter than water—to 7.5 lbs./gal. (56 lbs./cu. ft.) when drilling through depleted zones.

5 Lasts indefinitely

Black Magic can be used over and over again. One operator has used Black Magic continually for over a year, in a wildcat. Another is still using the Black Magic he purchased over 8 years ago. Black Magic can be regenerated easily with chemicals manufactured by Oil Base, Inc.

6 Thousands of successful jobs

Black Magic has been used in every conceivable type of well, under the most adverse conditions, yet has lived up to its promise in over 5,000 wells throughout the world. It will pay you to investigate the story of Black Magic.

Write for details and a free copy of the Black Magic Handbook.

OIL BASE PRODUCTS

OIL BASE, INC. MAIN OFFICE and PLANT: 130 ORIS ST., COMPTON, CALIF.

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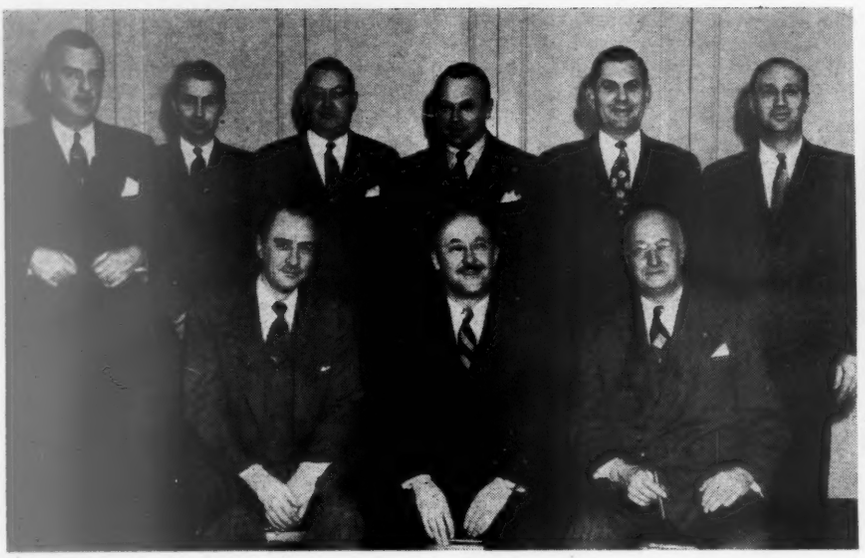


President Book, left, receives gavel from Henry McAdams, at New York Nomads meeting.

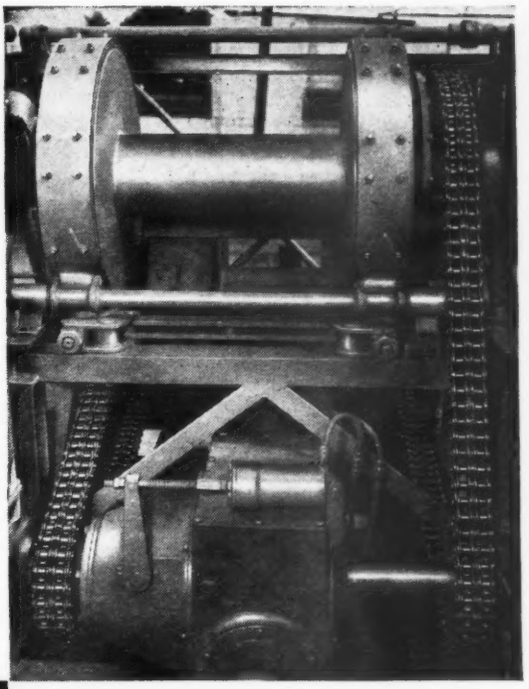
1951 Officers Named for New York Nomads

The New York Chapter of Nomads elected new officers for 1951 at its regular business meeting January 15. Officers, shown in the accompanying photo, are, standing: Henry J. McAdams, Jones and Laughlin Supply Company, regent; John D. Evans, Lucey Export Corporation, treasurer; R. (Bob) E. Elmore, Mid-Continent Cummins Export Corporation, assistant sergeant-at-arms; George I. Lynch, Lee C. Moore Company, assistant treasurer; Russ V. McIntire, Baker Oil Tools, Inc., sergeant-at-arms; Kenneth D. Demarest, The Fluor Corporation, Ltd., regent, and sitting, Fred J. Jobst, Val R. Wittich, Jr., secretary; Howard B. Book, Reed Roller Bit Company, president, and Al. Dill, Axelson Manufacturing Company, vice president. Arthur Harvey, Cardwell Manufacturing Company, Inc., assistant secretary, is not shown.

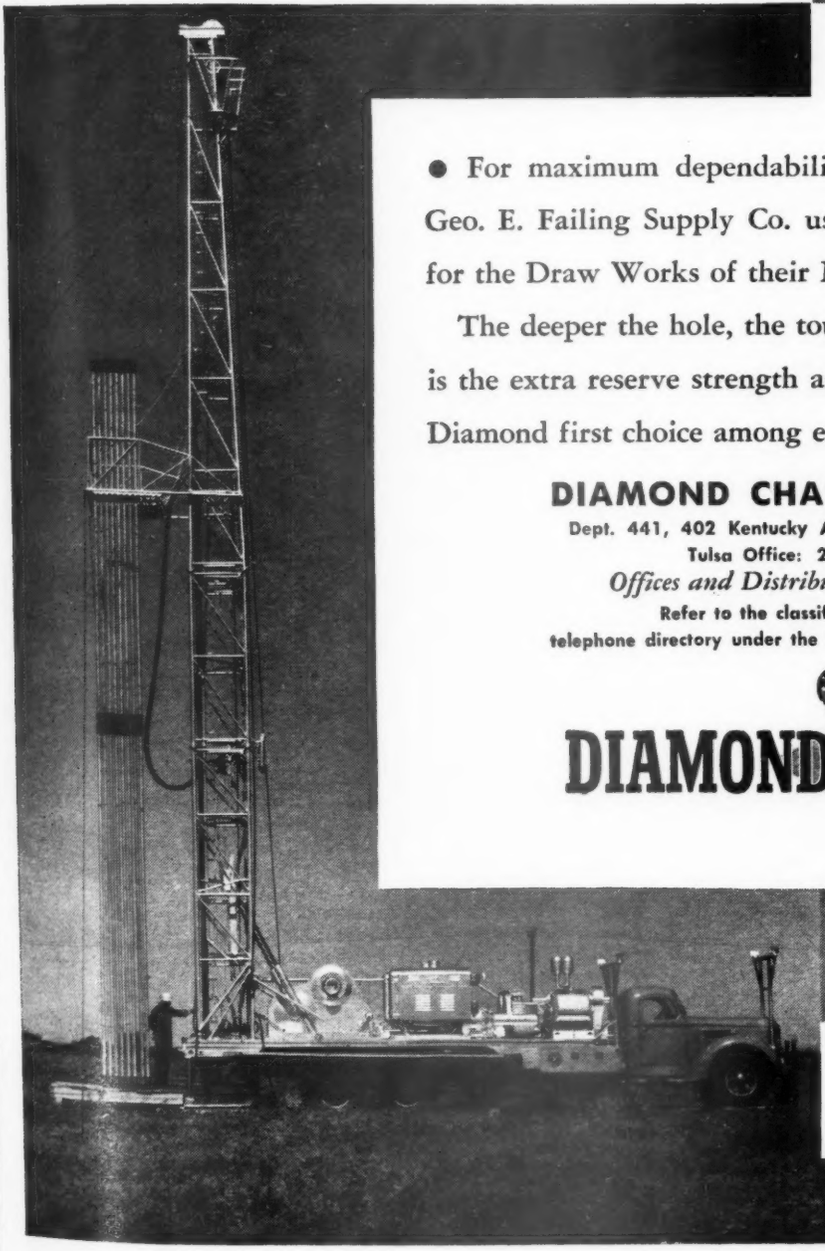
Sunray Production Men Meet in Tulsa

Sunray Oil Corporation's production department superintendents and district engineers throughout the Mid-Continent division met in Tulsa, Oklahoma, recently to map out their 1951 field operations program. The conference, which was called at the request of M. O. Harder, vice president, was presided over by J. R. Vandever, general superintendent. Pictured in the accompanying photo are the superintendents and engineers attending the conference, seated: Alvin Summers, Oklahoma City, superintendent; J. R. Vandever; H. O. Harder; John Douma and C. J. Kerwin, assistant general superintendents; Carl Wilson. Texas Gulf Coast superintendent. Standing: C. F. McCarroll, Tulsa office manager for production; Fred Goddard, Alice, Texas, assistant superintendent; Bob Chesney, Benton, Louisiana, superintendent; Perry Gill, Midland, North and West Texas superintendent; Fred McDaniel, Great Bend, Kansas, assistant superintendent; A. E. Hoffman, Lake Charles, Louisiana, superintendent; V. L. Smith, Wewoka, Oklahoma, assistant superintendent; G. E. McClatchey, Lewisville, Arkansas, engineer; C. C. Shreve, Great Bend, Kansas, superintendent; H. D. Jones, Lewisville, superintendent; Vaughn Knight, Snyder, Texas, superintendent; W. L. Horner, chief petroleum engineer, and Keith Lindley, Lewisville, engineer.

DIAMOND ROLLER CHAINS Add Extra Dependability on *Failing* HOLEMASTER



Enclosures removed to show the two Diamond double-strand Roller Chain Drives on Draw Works.



Model 2500 Holemaster Drill with Diamond Roller Chain Drives in Draw Works.

● For maximum dependability and extended service life, the Geo. E. Failing Supply Co. uses Diamond Roller Chain Drives for the Draw Works of their Model 2500 Holemaster Drill.

The deeper the hole, the tougher the job, the more important is the extra reserve strength and uniform quality that has made Diamond first choice among experienced oil country men.

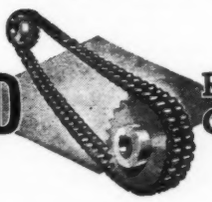
DIAMOND CHAIN COMPANY, Inc.

Dept. 441, 402 Kentucky Avenue, Indianapolis 7, Indiana

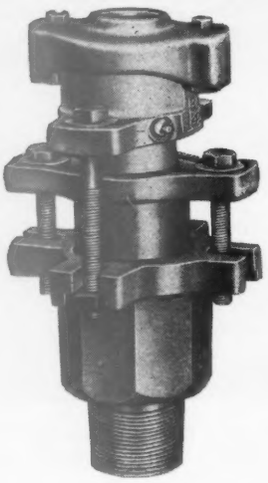
Tulsa Office: 2238 Terwilleger Blvd.

Offices and Distributors in All Principal Cities

Refer to the classified section of your local telephone directory under the heading CHAINS or CHAINS-ROLLER

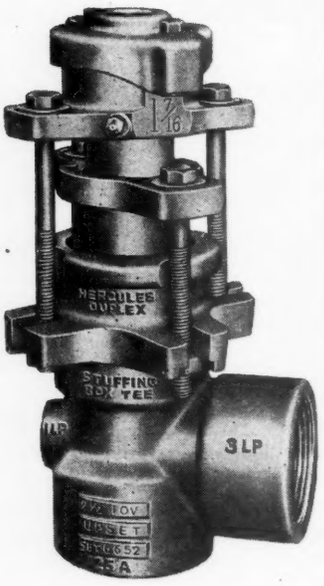
DIAMOND  **ROLLER CHAINS**

Hercules Red Tools
"Designed to Stand Out Built to Stand Up"

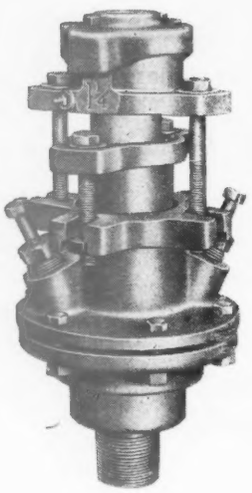


All Hercules Duplex Polished Rod Stuffing Boxes are Cone Packed for longest possible life and greatest economy. Illustrated (left) is Regular Type. Write for Bulletin 120-SB.

The Tee-Base Type Combination Stuffing Box and Tee (directly below) have been proven by years of service and savings to producers. Write for Bulletin 121-SBT.



A double packed Stuffing Box for use under most adverse pumping and flowing conditions (below). Be sure to order Type A-123-SBDP.



For greater savings, replace old style Upper Glands with the New Hercules Lubricating Upper Gland, as shown on Stuffing Boxes illustrated.

SOLD AT ALL SUPPLY STORES

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OIL FIELD EQUIPMENT CO., INC.
T. E. WARD, *President*
30 Church St., New York 17, N. Y.

HERCULES TOOL COMPANY
Manufacturers of Oil Field Equipment
General Office and Plant: 17th and Phoenix, P. O. Box 286 — TULSA, OKLAHOMA — Telephone 3-1186, Cable Address "HERTOCO"

Austrian Output Doubled, Government Reports Claim

Crude oil production has doubled in the last two years in eastern Austria, according to government officials. This has the familiar ring of most communist government reports. Despite this claimed increase Eastern Austria has stopped all oil exported to Western Europe. Heretofore, the Russians were eager to sell as much of their Austrian oil as possible to the west, mainly to Belgium and France, for dollars.

In December alone, production reached a record of about 155,000 tons, officials report. Two years ago, 67,000 tons were produced during the same period at the Zistersdorf fields, 20 miles north of Vienna.

The increase in production was the result of many new rich finds, officials said. The Russians seized the Zisterdorf fields in 1945 as a former German asset on the basis of the big three Potsdam rulings.

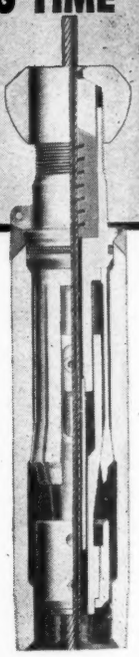
Officials report that late in 1950, Moscow ordered the Soviet oil administration office in Austria to halt all oil exports to western countries. In 1949, it was estimated, the Russians sold about 50 per cent of their total annual Austrian output to the west.

Alabama Production for 1950

Alabama produced 714,753 bbl of oil during 1950, according to figures released by Dr. Walter B. Jones, state geologist and oil and gas supervisor. Production for December alone amounted to 82,868 bbl, Jones reported.

At the end of the year Alabama had 60 producing wells. Of these, 25 are situated in the West Gilbertown field, and 33 in the East Gilbertown field of Choctaw County. Two are in the South Carlton field of Clarke County, Alabama.

REDUCE
BAILING and SWABBING TIME *with the* BOWEN AUTOMATIC LINE WIPER



THE BOWEN AUTOMATIC LINE WIPER is an inexpensive tool that will quickly "pay out" its cost by increasing efficiency and reducing time spent on bailing or swabbing work. With this completely automatic unit you can . . .

. . . KEEP THE WIRE LINE CLEAN
. . . PREVENT GAS AND FLUID LEAKAGE
. . . MAINTAIN A DRY and SAFE RIG FLOOR

No special attention is required for operation. When pulling out, the packer seals off tightly around the wire line, keeping gas and fluid inside the casing—not on the rig floor. **AND NO AMOUNT OF PRESSURE CAN BLOW IT OUT!** Yet, when struck by the outcoming rope socket, it releases instantly and rides out on top, relocking in the body automatically when the tools are lowered again. No unlocking . . . no resetting . . . and no need to "flag" the line.

The Bowen Line Wiper is available in sizes for all commonly used drill pipe and tubing connections. Order yours today!

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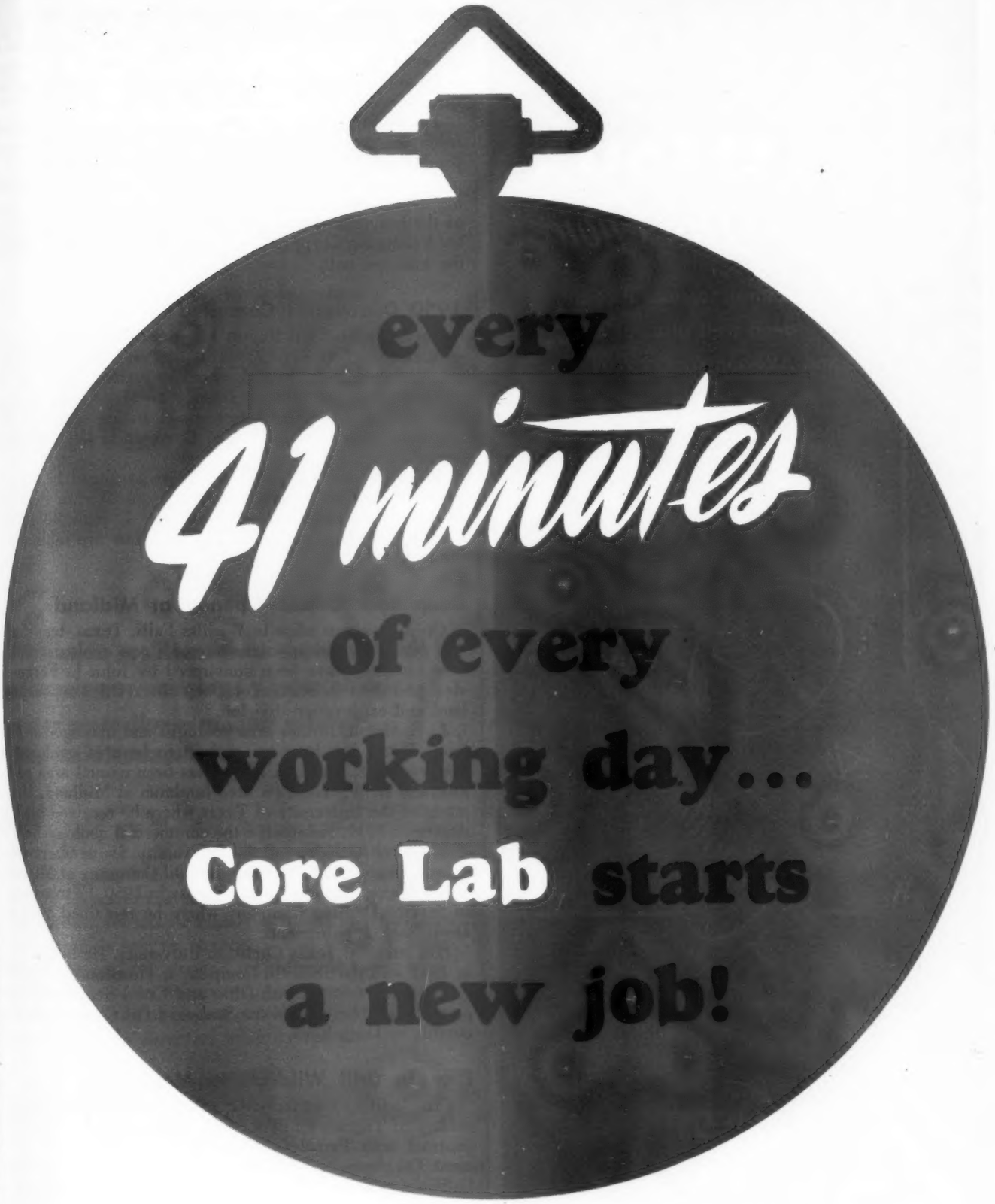
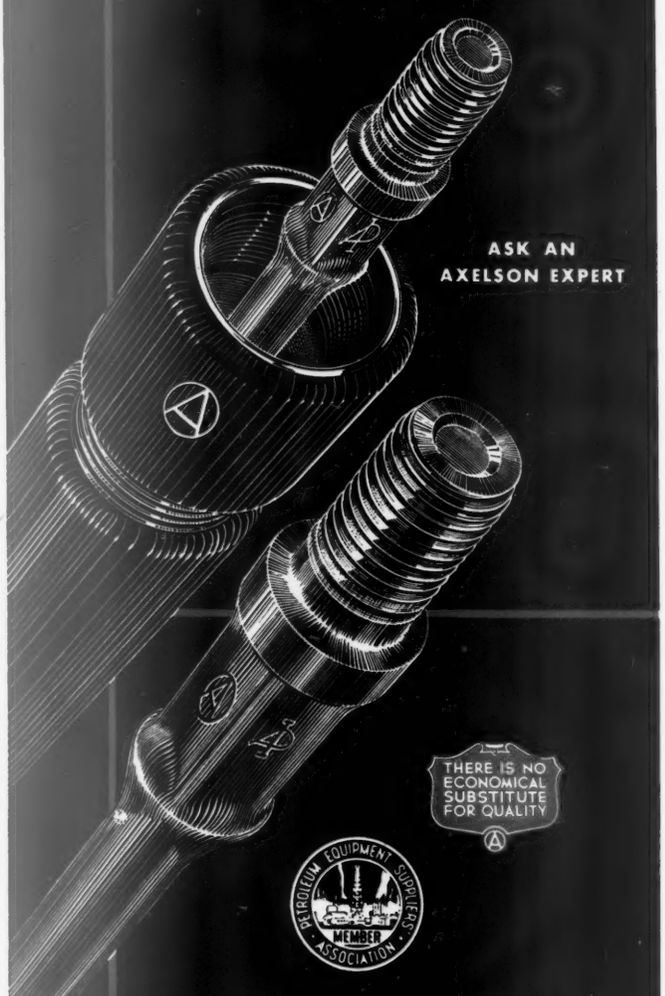


"Providing more reservoir revenue . . . through the production of more recoverable oil."

AXELSON
First Choice

The pumping team of Axelson deep well plunger pumps and Axelson sucker rods assures top performance under all pumping conditions.



ASK AN AXELSON EXPERT

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION MEMBER

AXELSON MANUFACTURING CO. • PLANTS—Los Angeles 58, St. Louis 16 • OFFICES—New York City 7; Tulsa 1; Buenos Aires, Argentina; Caracas, Venezuela • DISTRIBUTORS—Jones & Laughlin Supply Co.; Great Northern Tool & Supply Co; Industrial Agencies, Ltd., San Fernando, Trinidad, B.W.I.; Industrias Waldrip & Campbell, Barcelona & Maracaibo, Venezuela; Dominion Oil Field Supply Co., Ltd., Calgary, Canada; South American Supply Co., Avenida Tacna 592, Lima, Peru.

Penn Grade Group Forms Two New Units

The Pennsylvania Grade Crude Oil Association has announced the formation of two subcommittees to facilitate the handling of technical and fiscal matters resulting from the group's study of secondary oil recovery methods.

The technical unit will have a staff of Pennsylvania engineers and geologist, and executives of the state refining and producing companies will form the business group.

Professor H. G. Botset, head of the petroleum engineering department, University of Pittsburgh, will be chairman of the technical subcommittee, and G. W. Holbrook, Bradley Producing Corporation, Wellsville, New York, will head the business unit.

1950 Discoveries Compiled

The Five Star Oil Report has published its first book, entitled *Discoveries of 1950*. It is written by Frank J. Gardner, and consists of a comprehensive review of new oil developments during 1950 in Texas, New Mexico, and Coastal Louisiana. It is divided into sections, listing each new pool and the county in which it was dicovered in the areas mentioned.

Materials included in the book are arranged in sections and each section is individually indexed. Within each section are three categories of "discoveries"—new fields, new pools, and extensions. Maps and diagrams are included in the text.

Deep Rock Offices Opened at Midland

Opening a new office in Wichita Falls, Texas, transfer of one geologist, and appointments of a new geologist and an area landman have been announced by John L. Ferguson, vice president in charge of Deep Rock Oil Corporation's land and exploration division.

F. E. Melott, former area geologist and manager at Midland, Texas, has been transferred to be area geologist in the new office, and J. C. Meyer has been named area geologist, and H. W. Hitt, new area landman at Midland. Meyer attended the University of Texas where he received his B.S. degree in 1941. He entered the commercial geology field in 1947, after teaching at the University for a short time, through a position with Barnsdall Oil Company at Midland. When Barnsdall merged with Sunray in 1950, he transferred to Service Drilling Company where he remained until the Deep Rock appointment.

Hitt attended Texas Christian University. He began work in 1941 with the Shell Oil Company in Houston, then moved on for short tenures with Ohio and Cities Service oil companies. Later he worked for Seaboard Oil Company before coming to Deep Rock.

Pike To Drill Wildcats in Mexico

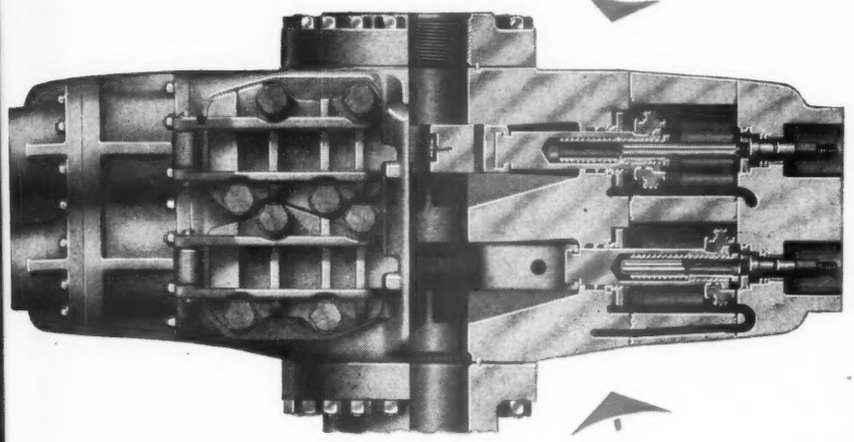
Pike Drilling Company de Mexico, a wholly owned subsidiary of Thomas P. Pike Drilling Company, has signed a contract with Petroleos Mexicanos, the Mexican Government Oil Agency, for the drilling of a wildcat in Baja, California, about 600 miles south of the Mexican Border and several miles inland from the Pacific Ocean. Pike is shipping a 10,000 ft diesel rig to the location and will set up a complete camp at the site. Tool Pusher Bill Klassen will be in charge of the operation, and several additional Pike employees will accompany him from California for the duration of the job.

It is anticipated a camp of about 50 men will be maintained and will be staffed by Pike Drilling Company and Pemex engineers. This well will be the first deep test of the area for several hundred miles in all directions and should be of considerable importance for the future of oil production in that part of the Pacific Coast area.

In the Shaffer Hydraulic Cellar Control Gate

ALL MOVING PARTS ARE COMPLETELY ENCLOSED!

Take a look at the clean design of the new Shaffer Hydraulic Cellar Control Gate. Note how all operating parts are COMPLETELY ENCLOSED within the body of the Gate.



1 There are no outside moving parts to become corroded by chemical muds or salt fluids dripping into the cellar!

2 There is nothing to become wedged or jammed by falling objects or loose timbers in the cellar!

3 There are no exposed shafts where mud and grit can collect to be carried into packing units, score shafts, cause leakage and early failure!

- **No corrosion problems from chemical muds!**
- **No jamming or wedging by loose objects!**
- **Greater protection—greater safety—less maintenance!**

In fact, not only are all moving parts protected within the body of the Shaffer Hydraulic Cellar Control Gate, but even the locking shaft is non-rising and completely protected at all times!

What do these features mean? Simply this—that Shaffer engineers have designed the Shaffer Hydraulic Cellar Control Gate to be safety equipment *of the most advanced type*—with no operating parts exposed to the severe conditions and unpredictable elements found in rig cellars.

Nothing is left to chance. When pressure emergencies occur you can depend on this unit being ready for *fast* and *complete* closure without interference from any foreign material or objects outside the body—*because they simply cannot interfere with its operation!*

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27 Years OF OIL TOOL LEADERSHIP

And Don't Forget These 4 Other Vital Features, Too!

Complete protection of the operating parts is only one of many important features found in the Shaffer Hydraulic Cellar Control Gate. These are equally important—

▸ **SPACE SAVING COMPACTNESS:** Although two separate ram compartments are unitized in *one* body, the overall height of the Gate, including both compartments, is only 30" in sizes as large as 13⅜" (12" Series 900). Smaller sizes even less!

▸ **SIMPLE RAM CHANGES**—the simplest in *any* Gate. Just unbolt and swing open a side door, slide out the ram assembly, slide in the new assembly, close and bolt the door. It's as simple as that—*and complete ram changes can be made whether pipe is in or out of the hole!*

▸ **QUICK DRAINING BODY:** The rams travel on high narrow guide ribs raised above the steeply-sloped bottoms of the ram compartments. Mud and sand quickly drain back into the well—no detrimental accumulations to interfere with free ram operation!

▸ **DIRECT HYDRAULIC DRIVE:** Hydraulic operating cylinders are *directly behind* the rams for direct action, maximum simplicity, greatest safety. No secondary connections between hydraulic cylinders and rams!

And there are still other important features—all combining to make the Shaffer Hydraulic Cellar Control Gate the most advanced *hydraulic* gate available today. Get full details from your Shaffer representative—or write direct!

Write for the new 1950 Shaffer Catalog that gives full information on the Shaffer Hydraulic Cellar Control Gate as well as other Shaffer products.

See pages 4433 to 4496 of your 1950 Composite Catalog!

WHAT'S DOING IN DRILLING

Pennsylvania Has Largest Appalachian Gas Well

A well described as probably the biggest gas well in the Appalachian area has been completed by Consolidated Natural Gas Company's subsidiary, New York State Natural Gas Company. Situated in the Leidy field near Lock Haven, Pennsylvania it has a calculated open flow potential estimated at between 100,000,000 and 120,000,000 cu ft per day. Previous largest well in the field was the company's No. 1 Daugherty with an open flow potential of 61,000,000 cu ft daily.

Texas Well Completed

Independent Exploration Company's subsidiary, Intex Oil Company, and Dancinger Oil and Refining Company have completed their Gerald No. 1, discovery well in Fisher County, Texas. The new well is pumping 65 bbl a day of 38 deg gravity clean oil.

Gas Condensate Area

A new Wilcox sand gas-condensate area has been opened in Austin County, Texas, at Sun Oil Company's No. 1 Mikeska. The new well flowed 6 bbl of condensate an hour through a 1/8-in. choke from 9313-23 ft on initial gage. Flowing pressure was 1900 lb.

Utah Wildcat Staked

The California Company has announced location for an important deep test in the St. George area of Washington County, Utah. The wildcat is planned as a test of the Devonian formation at about 7000 ft.

Carter Tries for New Well In Old Abandoned Pool

Carter Oil Company is going back to an old once productive area in McClain County, Oklahoma, and try for another well. The area is the old West Noble field, the now abandoned field discovered by Carter in 1944. The No. 2 N. R. Johnson will be drilled to 9000 ft to test the Oil Creek formation, and will be twin spot to the No. 1 N. R. Johnson, that opened the Bromide production for awhile between Noble and Goldsby. The one-time discovery was taken to 8222 ft, and produced for about 7 months after completing late in 1944. Too much water resulted in the zone's being squeezed several times, with the well eventually being plugged.

Sun Oil Well Flows 1761 Bbl in 24 Hours

One of the largest wells ever brought in in the Velma pool, Stephens County, Oklahoma, has been completed by Sun Oil Company. It is the No. 5 Robison, which has been drilled to a total depth of 5558 ft. The new well flowed 1761 bbl of 32 gravity oil in 24 hours from the Velma sand, through casing with a 2-in. opening into tanks. With 7-in. casing set at 5184 ft, the Velma sand was found from 5181 ft to 5466 ft, with 18 ft additional below a break and to 5506 ft.

Tests Second Zone In Oklahoma Field

Amerada Petroleum Company is testing a second zone in the Starr Valley pool of Payne County, Oklahoma. The new well is the No. 1 White, which is showing a small amount of oil from the Red Fork sand. An east offset to the W. H. Elson No. 1 Hesser, the White swabbed 15½ bbl of oil in 24 hr from open hole at 399-95 ft, and was making 300,000 cu ft of gas daily.

New Mexico Wildcat To Go Down to 13,500 Ft

A 13,500-ft Devonian exploration has been staked in Lea County, New Mexico by Magnolia Petroleum Company. The test will be drilled in partnership with Mid-Continent Petroleum as No. 1-15 Four Lake unit-State 12 miles southwest of the Crossroads field.

New Well In Garvin County

Carter Oil Company has completed its No. 1 Stephens-High Estate in Garvin County, Oklahoma for a flow of 284 bbl of 41 gravity oil in 13 hr. Oil flowed through a ¾-in. choke, from a plugged back depth of 7478 ft, with a gas-oil ratio of 1240 to 1. Flow was from the first Bromide sand through perforations between 7351-55 ft after treatment with 250 gal of mud acid.

Kansas Gets 24th Pool

Pawnee County, Kansas is the scene of that state's 24th oil pool for 1951. It is Stanolind Oil and Gas Company's No. 1 Evers, more than 6 miles southeast of the Ash Creek pool. The well was assigned a rating of 58 bbl of oil daily from the Lansing lime through perforations at 3525-31 ft. The pool is as yet unnamed.

Drilling in Tidelands To Stop, Hallanan Warns

Oil exploratory and drilling activities in the Gulf of Mexico have been sharply curtailed and will soon be stopped entirely, Walter S. Hallanan, president of Plymouth Oil Company, has warned. He urged immediate clarification by Congress of the tidelands.

Hallanan, in a letter to Senator Joseph C. O'Mahoney, chairman of the Senate Committee on Interior and Insular Affairs, reported that the number of geophysical crews working in the Gulf have decreased from 48 to 5, and that the number of drilling rigs have dropped from 26 to 9. He pointed out that when the 9 wells now drilling are completed there will be no more drilling in the Gulf because of an order by the Interior Secretary forbidding the completion of any wells begun after December 11, 1950. In his letter, Hallanan reported that oil operators held leases issued by the states of Texas and Louisiana covering 1,549,987 acres of submerged coastal lands. A total of 233 wells have been drilled in the area, resulting in 89 oil wells, he informed O'Mahoney, 28 gas condensate wells, 4 dry gas wells, and 112 dry holes. Texas gulf production up to December 1, 1950 was 8,375,877 bbl.

Large Oklahoma Well

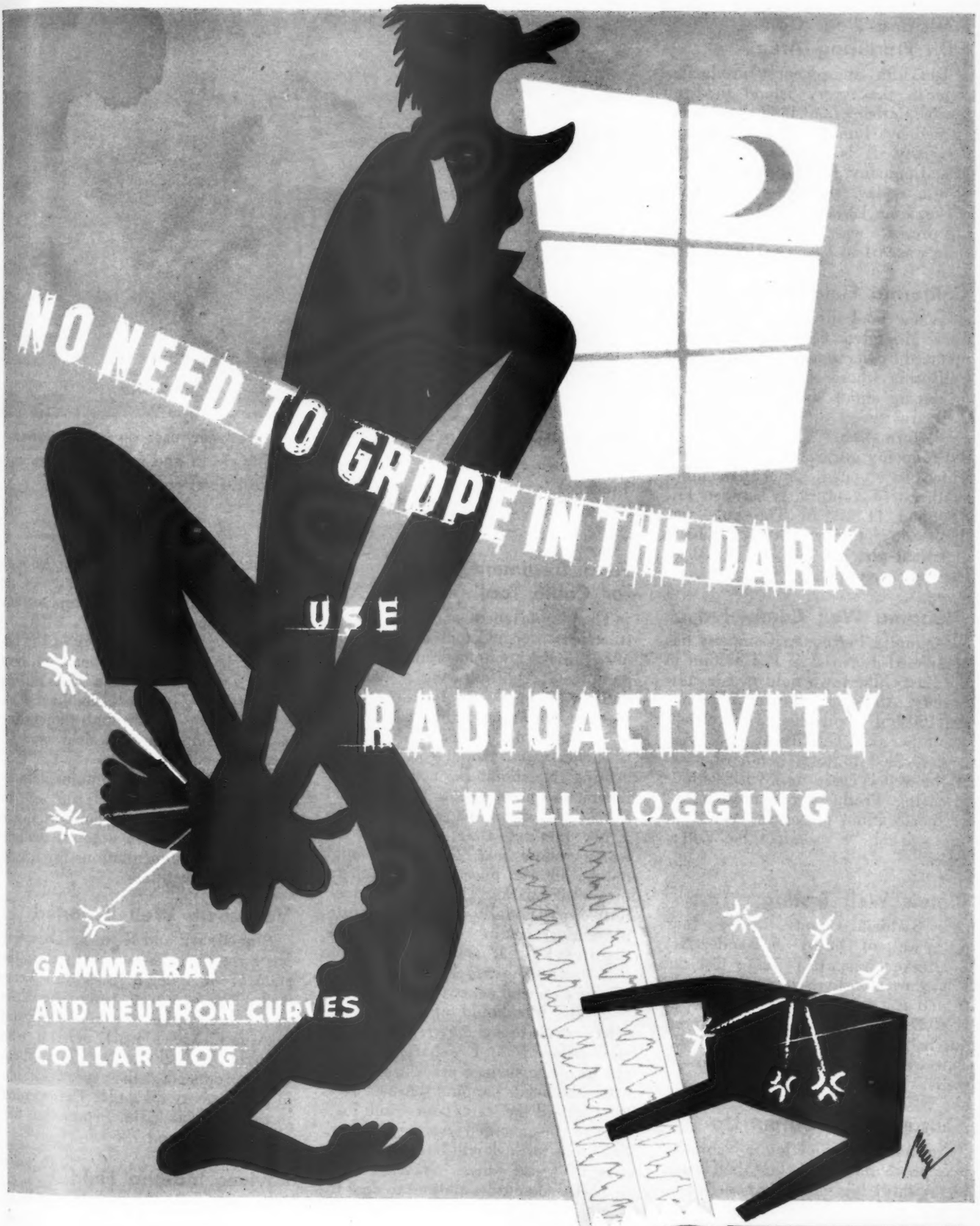
Peppers Refining Company has completed a large oil well in the Beaver Creek pool of Stephens County, Oklahoma. It is the No. 1 Adkins, a north 40-acre offset to the discovery well. The new well flowed 840 bbl of 38 gravity oil in 9 hr through 2-in. tubing. Pinched by 12/64-in. choke it flowed 230 bbl in 24 hr.

Ohio Well Promising

Ohio Fuel Company may have a new pool opener at its No. 1 G. C. Krueck in Lorain County, Ohio. The new well topped a sand at 2583 ft and gaged 265,000 cu ft of gas at 2586 ft.

New Well in Kingston Field

Magnolia Petroleum Company's No. B-1 Tyler-Swayze in the Kingston field of Adams County, Mississippi is the best producer to date in that location. It was completed flowing 312 bbl of 39-gravity oil per day through 12/64-in. choke under tubing pressure of 600 lb and casing pressure of 450 lb. Gas-oil ratio was 300 to 1.



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Louisiana Field Gets Fifth Producing Area

The fifth and deepest producing zone in the Avery Island field of Iberia Parish, Louisiana has been opened by Humble Oil and Refining Company. It is the No. B-21 Petit Anse Company, which flowed 641 bbl of oil a day, through a 12/64-in. choke, from 12,779 to 12,185 ft. Tubing pressure was 2500 lb, and gas-oil ratio was 961 to 1.

California Field Well

A new pool discovery in California's Montalvo field has been announced by Standard Oil Company of California whose McGrath 148-12 is producing about 200 bbl per day of 20.6 gravity oil on a test from the Sespe formation.

Producing interval of the new well, which is situated about five miles southeast of Ventura, is between 11,810 and 11,821 ft. The hole was drilled to a total depth of 12,110 ft and then plugged back to 11,831 to test the Sespe sands.

Alabama Well Completed

Magnolia Petroleum Company has completed its No. 2 A. P. Chestnut in the East Gilbertown field of Choctaw County, Alabama. The well is pumping 100 bbl of oil plus 84 bbl of salt water per day. Gravity of oil is 17.8 deg. Drilled to total depth of 3400 ft, the well is cased to 3396 ft with 7-in. string. Production is through casing perforations placed at 3344-47 ft, opposite the "F" sand of the Eutaw series.

Illinois Well Testing

In Richland County, Illinois, four miles west of Olney, Joe Bander No. 2 Diesser has set pipe to test the Rosiclare limestone at 2978 to 2983 ft, and at 2994 to 2996 ft. Total depth is 3029 ft. A drillstem test recovered gas in 20 min, and oil flowed in 42. This well is one mile from other oil wells.

Nebraska Gas Output Up

Natural gas production in Nebraska may prove more important than crude oil. A third big gasser is being completed in Big Springs field by C. B. Edmondon and Ideal Drilling Company. Situated in Deuel County, the well has been gaged 2,250,000 cu ft of gas daily from the "D" sand, Dakota series.

In the Huntsman field, Ohio Oil Company is continuing an active development program. The firm's No. 1 Rippe, was recently completed for a gage of 10,000,000 cu ft daily.

Marvin Boyer of Iola, Kansas, driller and producer, uses an International truck shown above to haul a heavy Star drilling rig to and from drilling sites. The truck is supplied by the local International Harvester dealer.

Field Treatment of Bits for Cable Tool Drilling

The importance of proper field treatment of cable tool bits to minimize failures is emphasized in a recent pamphlet.* The following recommendations are made for heating, dressing, and tempering the bits in the field:

1. Bits should be heated slowly until a cherry red (about 1600 F), then heating rate should be increased until the bit is lemon yellow (about 2100 F). The bit should be removed within a few minutes after it reaches the lemon yellow heat. The steel should not be allowed to get hot enough to throw off sparks. The bit should be turned occasionally during heating to prevent overheating one side. The time required to heat a 6⅝-in. bit from cold to dressing temperature is about 45 min in a well constructed forge.

2. The bit should not be dressed after it cools to a cherry red. Sledging steel below 1600 F (cherry red) is apt to cause surface cracks that cannot be mended. Lapping the steel over the edges of the water course and lugs should be avoided when dressing. Laps that form should be cut out with a round nosed gauge.

3. Bits should be allowed to cool to about 900 F (black) after dressing and then reheated to cherry red (about 1600 F) for quenching. Bits should never be quenched from the end of a dressing heat, as this will cause coarse, brittle grain structure, existing at high temperatures, to remain in the steel.

4. Bits should be quenched in clean, cold water just deep enough to cover the cutting faces but not deep enough to cover the corners or lugs. Cold water should be added to replace any water that boils away.

5. For proper tempering of the bit, during the quenching operation, heat about 6 to 8 inches of the blade during the hardening or quenching heat. This heat, running out through the cutting edges, accomplishes the draw and relieves quenching strains.

The pamphlet also contains data on the weight, length, and pin size of bits for drilling holes from 3-in. to 15-in. in diam; data on weldless drilling jars, and recommendations for breaking in new bit joints.

*Published by Acme Fishing Tool Company, Parkersburg, West Virginia.

Venezuela Well Reported

Sinclair Oil and Refining Company has brought in a second oil well in the state of Anzoategui in eastern Venezuela. The new well, Guere No. 2, is about three-eights of a mile northwest of Guere No. 1 well, which was brought in last October. The Guere No. 2 produced at the rate of 456 bbl of 33.6 gravity oil daily. The opening in the pipe was ⅜-in. Production was between 7846 and 7866 ft.

Revives Indiana Field

A prospective Cypress sand discovery has been made by J. C. Haynes and Nathan Berkman in the old, abandoned oil and gas producing area situated in Gibson County, Indiana. The operators' No. 1 Gilvie and McDowell found good saturation in the Cypress, logged at 1462-71 ft and following a 50-min drillstem test, had 1000 ft of gas, 650 ft of clean oil, and 90 ft of oil-cut mud in the pipe.

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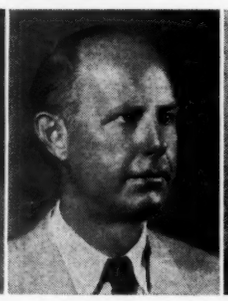
EXPLORATION ACTIVITIES

Morgan Elected AAPG President for 1951

Frank A. Morgan, vice president and manager of exploration, Richfield Oil Corporation, Los Angeles, California, has been elected as the 35th president of the American Association of Petroleum Geologists. Other officers elected include Lewis G. Weeks, Standard Oil Company (New Jersey), New York City, as incoming vice president; Robert H. Dott, Oklahoma Geological Survey, Norman, Oklahoma, as secretary-treasurer; and Kenneth K. Landes, University of Michigan, Ann Arbor, Michigan, as editor of the monthly Bulletin of the AAPG. This completely new slate of officers will take over its Association duties at the close of the 36th annual meeting of the AAPG, to be held this April 23-26, in St. Louis, Missouri. Retiring officers of the Association are president, C. L. Moody, division geologist, Ohio Oil, Shreveport, Louisiana; vice president, John Emery Adams, geologist, Standard Oil of Texas, Midland; secretary-treasurer, Henry N. Toler, manager of the geological and land department, Southern Natural Gas Company, Jackson, Mississippi; and editor, Alfred H. Bell, head of the oil and gas division, Illinois State Geological Survey.

Frank A. Morgan



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R. H. Dott

K. K. Landes

The incoming president studied geology at the University of California during 1916-20, except during his military service in 1918. Graduating from Berkeley with an A.B. degree in geology in 1920, Morgan began his career in petroleum exploration as a geological consultant and evaluation engineer. He was appointed vice president and chief geologist of the Rio Grande Oil Company, with headquarters in Los Angeles, California in 1929. In 1937, Morgan accepted the position as manager of the exploration department of the Richfield Oil Corporation. Subsequently promoted to the position of vice president in charge of exploration, Morgan is now in his 14th year of service to Richfield. Morgan was active in founding the Pacific Section of the AAPG in 1925, and in 1933, served as president of the Pacific Section. With A. I. Levorsen as president, Morgan served as vice president of the Association in 1935.

Weeks, vice president elect of the Association, is chief research geologist of the Standard Oil Company (New Jersey), New York City. He attended the University of Wisconsin, receiving his A.B. degree in geology in 1917. After graduation Weeks accepted a position as geologist and mining engineer at the Cananea Consolidated Copper Mining Company, Sonora, Mexico.

In 1920 Weeks accepted a position as petroleum geologist with the Whitehall Petroleum Corporation, Ltd., London, England, and during the next 4 years was engaged in geological work in the Orient, principally in India. In 1924, he became a geologist for Standard (New Jersey) and spent 9 years in South America.

Weeks has been active in the affairs of the AAPG for a number of years. During 1943-45, he served on the Association business committee; during 1946-48, he was a member of the research committee, and he has recently completed a nation-wide lecture tour under the sponsorship of the AAPG distinguished lecture committee.

The incoming secretary-treasurer of the AAPG, Dott, has been director of the Oklahoma Geological Survey, Norman, Oklahoma, during the past 15 years. Dott received his B.S. degree in forestry from University of Michigan in 1917 and then took a geological position with the Empire Gas and Fuel Company, and was engaged in subsurface work in Oklahoma, Kansas, and Texas.

For the past 20 years, Dott has served as an associate editor of the AAPG Bulletin. Other services to the Association include his serving as a trustee of the research fund, and membership on the research and other important committees.

Joining the AAPG in 1937, Landes has been active in committee work during the past 10 years. He has served on the committee on college curricula in geology; the committee on applications of geology, serving as its chairman during 1946-48; and is a member of the AAPG distinguished lecture committee.

Tests Indicate New Field In Crockett County, Texas

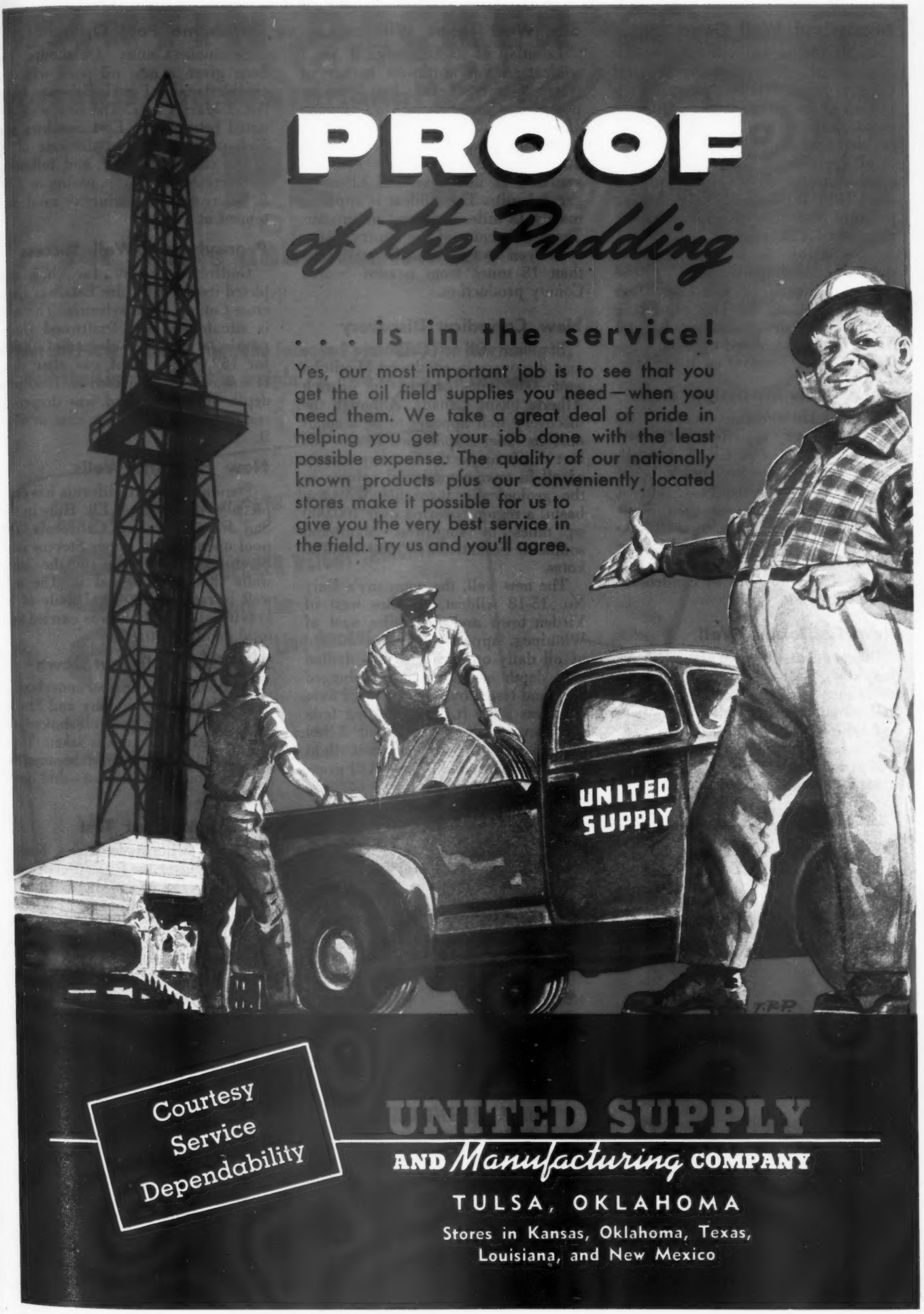
Continental Oil Company has reported tests at its C. T. Harris No. 1 in Crockett County, Texas indicate a new field has been opened. Projected for 9500 ft as an Ellenburger test, the well, on drillstem test from 8576 to 8635 ft, flowed at the rate of over 2000 bbl daily through a ¾-in. choke. Gas flow was rated 7664 cu ft daily with gas oil ratio of 3259 to 1. Nearest shallow production is about 7 miles east, in the Old World pool. Nearest deep production is about 12 miles north, in the Big Lake field, and 12 miles southeast in the Todd field.

Montana Well Testing

Carter Oil Company has recovered oil about 100 ft below the top of the Madison lime in its Blackfeet reservation wildcat at Coyote Springs, Glacier County, northwest of Cut Bank field, Montana. Oil was discovered on a drillstem test of a porous zone at Carter's Blackfeet reservation wildcat. Madison in the Blackfeet No. 1 was topped at 3570 ft and the well made light yellowish green oil between 3646-70 ft, total depth.

Kansas Well Has Oil Shows

A good showing of oil has been made at a Kansas wildcat, the first show of oil for the county of Pottawatomie. Oil was reported to begin showing in the mud after the rig struck the Wilcox sand at 1728 ft. The well was brought in by Leo B. Wentworth and associates of Wichita.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Mississippi Well Good

I. P. LaRue has opened the first commercial production in Forrest County, South Mississippi with completion of its No. 1 Creosote Oil Corporation. Flow was through a 12/64-in. choke at the rate of 1,686,000 cu ft of gas plus 27 bbl of 62 gravity condensate per day. Tubing pressure was 2480 lb, bottom hole flowing pressure 3080 lb with gas-condensate ratio of 61,425 to 1.

Production is being obtained through casing perforations placed opposite a sand of the Tuscaloosa zone at 7722-25 ft. The producing area has been designated as the Pistol Ridge field. Calculated open flow potential was 19,500,000 cu ft per day.

Opens New Mississippi Area

Sinclair Oil and Gas Company has a new discovery in Jefferson County, Mississippi at its No. 1 R. T. Liddell. Latest gage on the well using ¼-in. choke recorded a flow of 11 bbl of 57.8 gravity condensate per hour from the perforated interval at 10,-072-81 ft. Estimated potential of the well on ¼-in. choke was 2,500,000 cu ft of gas and 264 bbl of condensate per day.

New California Well

Independent Exploration Company's No. 1 Means is a new producer for Kern County, California. The well, situated between Mountain View and Edison, was completed as a 175-bbl flowing - pumping producer of 21.8-gravity crude in the Chanac sand at 4267-4608 ft.

Site West Texas Wildcat

Location of its Etheredge B No. 1 wildcat in the northwest corner of Nolan County, Texas, has been reported by Cities Service Oil Company (Delaware). The Ellenberger test is expected to drill to approximately 7600 ft, testing both the Pennsylvanian reef limestone and Ellenberger dolomite. The wildcat is approximately 18 miles southeast of Snyder, Texas, oil center of the Scurry County canyon reef play, and slightly less than 18 miles from nearest Scurry County production.

New Canadian Discovery

Standard Oil of California has a new discovery in southwest Manitoba some 600 miles east of the oil-rich Alberta basin, Canada. Although the discovery well appears to be a small one, its chief importance lies in the fact that it marks the first appearance of oil in near commercial volume in the geologically favorable Williston basin, a region covering over 100,000 sq miles in southwest Manitoba, southeast Saskatchewan, and the Dakotas.

The new well, the company's Daly No. 15-18 wildcat, 9 miles west of Virden town and 170 miles west of Winnipeg, appears good for 60 bbl of oil daily on pump. It was drilled to a depth of 5368 ft, and plugged back and tested by stages. Top of final plug was 2340 ft. On swabbing tests over several days, it yielded 3 bbl hourly, roughly 70 per cent light crude oil of around 35 deg API gravity and 30 per cent water.

Oklahoma Pool Opened

Seminole County, Oklahoma, has been given a new oil pool with the completion of Powel Briscoe, Inc.'s No. 1 Mary Casey. The new well, situated between the East Sasakwa and Fish pools, flowed at the rate of 20 bbl of crude per hour, and following tests, crews ran 5½-in. casing to 2770 ft. Gilcrease, the productive sand, was topped at 2720 ft.

Pennsylvania Well Success

Godfrey L. Cabot, Inc., has completed its No. 1 Pardee Estate in Cameron County, Pennsylvania. The well is situated on the Driftwood Quadrangle, at 6789 ft, elevation 1616 ft for 152,000 cu ft of gas after shot. It was originally drilled in 1947 to a depth of 3187 ft and was deepened, reaching the Onondaga lime at 6719 ft.

New Elk Hills Wells

Standard Oil of California has completed a new well at Elk Hills in the San Joaquin Valley, California. The pool opener is an upper Stevens sand heretofore passed up in the other wells that encountered it. The new well is rated a 2900 bbl daily of 34 gravity oil. The hole was carried to a total depth of 7016 ft.

Sour Gas Well Shut Down

In Bedford County, Pennsylvania, South Penn Oil Company and Eberly and Snee's Miller gas well showed gas at 8860 ft. No gage was taken. Tools were stuck in hole, and because the gas was sour, the well was shut down at 8860 ft.

Kansas Wildcat Test

A rank wildcat for West Kansas was announced by Cities Service Oil Company (Delaware) in its Coberly No. 1 in Gove County. Projected depth of the well is 4800 feet, with the Mississippian formation indicated as the main objective.

The test is situated approximately 28 miles northwest of the Ness County Arnold pool—nearest commercial production. At present Gove County is not an oil-producing county, although there has been some exploratory drilling.

Great Lakes to Explore Rocky Mountain Area

Great Lakes Petroleum Company of Chicago, Illinois has completed negotiations for leasing about 80,000 acres of federal and state land between Casper and the Castle Creek in Wyoming. An exploratory drilling campaign of at least six wells is planned in the first Rocky Mountain activity of the company.

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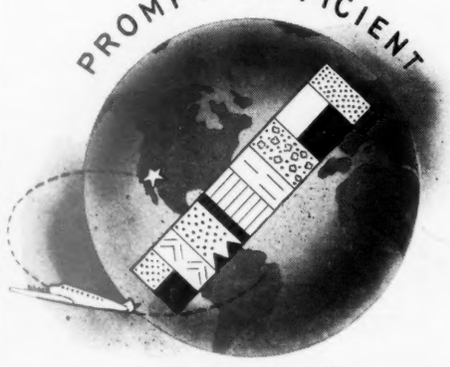

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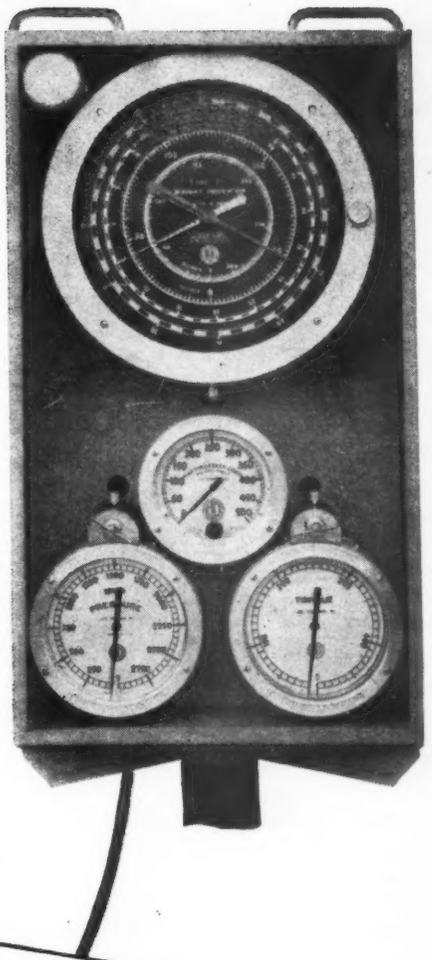

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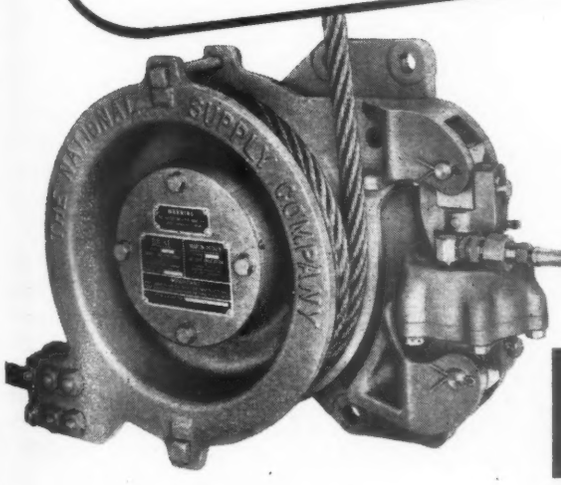

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Running tour with men in the industry

Paul F. Barnhart

Paul F. Barnhart, consulting petroleum engineer and independent oil operator, has opened his own offices, 1228 Commerce Building, Houston, Texas. Since February, 1942, he has been associated as manager of operations with Frank and George Frankel, independent oil operators, 1907 Commerce Building, Houston, having actively assisted the Frankels in developing substantial oil properties.

A large part of Barnhart's time will be devoted to his personal oil operations and consulting work. Barnhart attended Texas A. & M. College and graduated from the University of Oklahoma as a petroleum engineer in 1937, having had over two years active field work before receiving his degree. He was employed by Barnsdall Oil Company from 1936 to 1942 in various positions in drilling and production operations. His experiences for the past 15 years include active supervision of acquiring, drilling and production operations, as well as administration, of many properties developed in Texas, Arkansas, Mississippi, Louisiana, and Oklahoma.

Herbert D. Hadley, consulting geologist, was elected president of the Billings, Montana Geological Society recently succeeding **L. J. Fulton,** geologist with the Pure Oil Company. **John T. Mullen, Jr.,** geologist with the Northern Pacific chief geologist's office, was named vice president; **Miss Lorraine E. Hoyle,** geologist with Pure Oil Company, secretary, and **Frank P. Sonnenberg,** Amerada geologist, treasurer.

W. D. Henderson has been elected president of the West Texas Geological Society for 1951. A Midland consulting geologist, Henderson succeeds **John M. Hills. Alan B. Leeper,** assistant manager of exploration, West Texas division, Honolulu Oil Corporation, will succeed **J. H. Partley** as vice president. **Roy M. Huffington,** special problems supervisor, Humble Oil and Refining Company, was named secretary, succeeding **H. L. Williams. C. H. Atchison,** district geologist, Honolulu Oil was elected treasurer of the organization, succeeding **L. C. Mills.**

O. P. Brown has been put in charge of the New Wilshire Oil Company office at Denver, Colorado. He was formerly with Shell Oil Company.

E. E. Byrd, Humble Oil and Refining Company, production department, was transferred from Gulf Coast division to Winters district, North Texas division, for work as assistant district superintendent. **Riley A. Aucoin,** assistant division petroleum engineer, was transferred from East Texas division to Louisiana division as supervising petroleum engineer.

Philip E. Barber, Jr., division civil engineer, was transferred from Gulf Coast division to East Texas division as division civil engineer. **Harry D. Dickson,** senior supervising civil engineer, was transferred from Civil Engineering division in Houston to Gulf Coast division as division civil engineer.

W. J. Bielstein, senior petroleum engineer, was transferred from the petroleum engineering division in Houston to Southwest Texas division for work as supervising petroleum engineer. **Jack M. Shepherd,** supervising petroleum engineer, East Texas division, was promoted to assistant division petroleum engineer.

J. G. Calvert, district petroleum engineer of the London district, East Texas division, was transferred to the East Texas division office as a supervising petroleum engineer. **B. E. Crowder,** district petroleum engineer of the Talco district, East Texas Division, was transferred to the London district to replace Calvert, and **George C. Edgerton,** a petroleum engineer in the East Texas division office was transferred to the Talco district replacing Crowder.

E. J. Marti

E. J. Marti has been appointed supervisor of operations for United Geophysical Company in the Middle East area. Marti has had many years experience in geophysical exploration both domestic and foreign, and is now residing with his family at United's headquarters in Kuwait on the Persian Gulf. He was formerly employed by Independent Exploration Company in Colombia.

Hugh F. Boggs, for many years general superintendent of production for Richfield Oil Corporation, passed away on February 12, 1951 at the age of 60. His death was the result of a heart ailment from which he had suffered for some time. Boggs first began work for Richfield in 1926 as production superintendent at Huntington Beach and two years later was transferred to Long Beach as superintendent there. Subsequently he was made general superintendent, but when stricken by sickness was at his own request relieved of some of his more onerous responsibilities and returned to the Long Beach district. The late Paul N. Boggs, former vice president of Union Oil Company, was a brother of the deceased.

Norman D. FitzGerald of Abilene, Texas, has organized the Saxon Drilling Company in partnership with **D. D. (Flossie) St. John** formerly of Olney and Ballinger. He will supervise field operations. The new company has a rotary rig adapted for drilling wells from 2000 to 4000 ft deep in West Central Texas.

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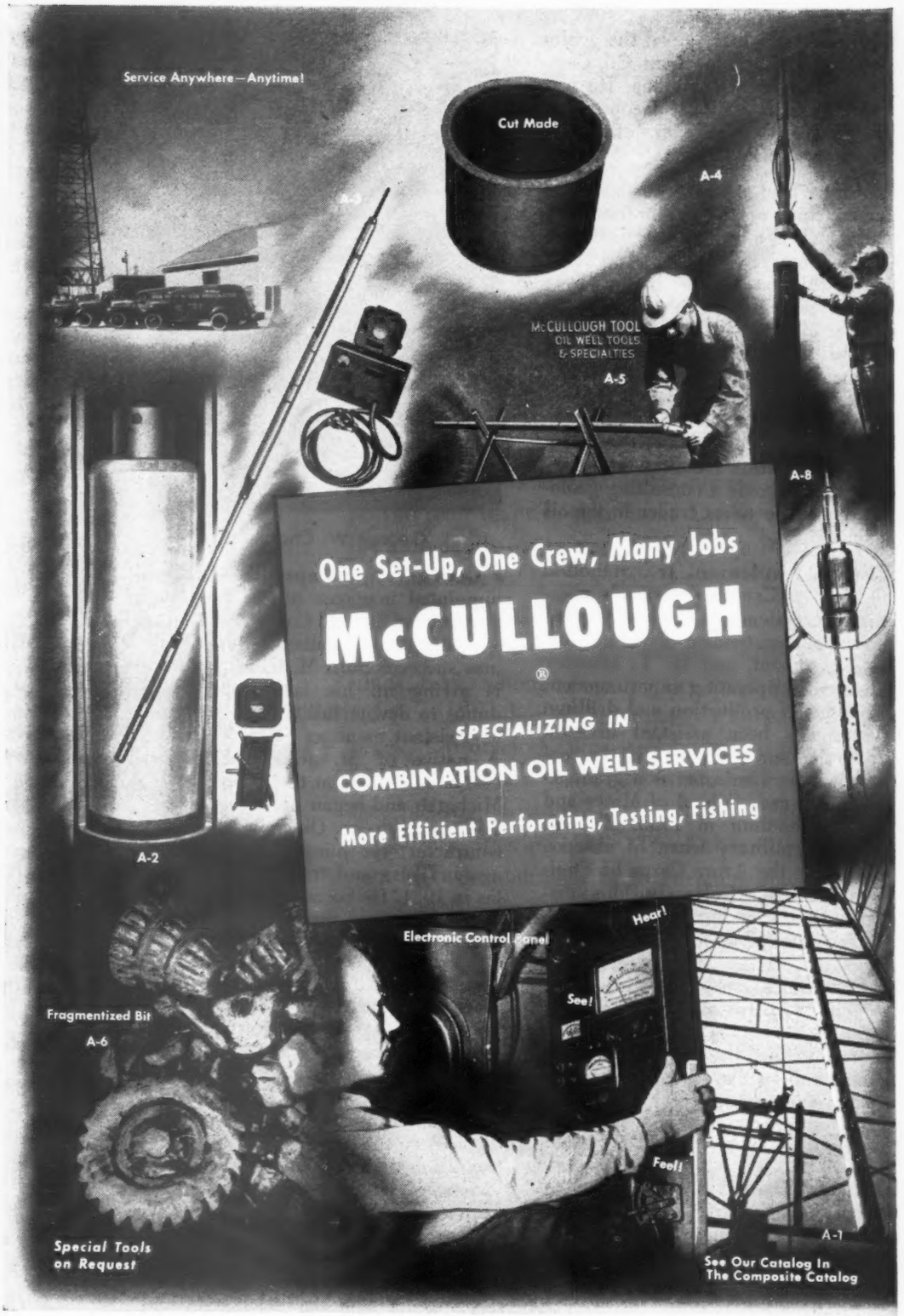

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John Avilla, has joined the geological department of Ryan Oil Company at Evansville, Indiana. He was formerly with National Geophysical Company of Dallas, Texas in the Henderson, Kentucky district.

Lamar McLennan, Jr., has been named chief of the exploration and geological department of Seaboard Oil Company's West Texas district office in Midland, Texas. He has been district geologist in this area for a number of years, with the supervisory responsibilities of the exploration department divided between him and **George R. Gibson.** Gibson resigned as geological coordinator for Seaboard in West Texas for 3 years prior to his resignation from the firm January 1, to become a consulting geologist and independent trader in the oil business.

Frank Lindeman, Jr., Stanolind Oil and Gas Company formerly operating superintendent, has been named general superintendent of the producing department, and **H. T. Hunter** will become operating superintendent in charge of production and drilling. Hunter has been assistant division production superintendent in the central division. Lindeman is a graduate of the Colorado School of Mines and joined Stanolind in 1933. He was granted a military leave of absence to serve in the Army Corps of Engineers in 1942. Following his discharge four years later with the rank of Lieutenant Colonel, Lindeman returned to Stanolind. He was in charge of Stanolind's marine operations in the Gulf of Mexico prior to becoming operating superintendent in 1949. Hunter attended the University of Oklahoma and received his degree in petroleum engineering from Tulsa University in 1934 and joined Stanolind that same year.

J. M. Wilson has been promoted from assistant district superintendent to district superintendent, central district, El Campo, Texas, South Texas division, The Texas Company, producing department. He will succeed **W. F. Batson,** who retired. **E. A. Staples,** field foreman, was advanced to assistant district superintendent to replace Wilson.

Wilson was graduated from Texas A. and M. College in 1935 with the B.S. degree in petroleum engineering. He began to work for The Texas Company as a roustabout in 1935. In 1940 he was made petroleum engineer. Staples was born at Edna, Texas, and received the B.S. degree at Texas A. and M. in petroleum engineering in 1938, when he also was employed by the company as a rotary rig helper.

George W. Chapman

George W. Chapman has been appointed manager of the land department of Sun Oil Company's southwest division at Dallas, Texas. Chapman succeeds **Sam M. Gladney,** who is giving up his land department duties to devote full time to his post as assistant manager of the division. A native of St. Johns, Michigan, Chapman studied at the University of Michigan and began his career in petroleum with an Oklahoma drilling contractor. He joined Sun 21 years ago in Tulsa and transferred to Dallas in 1931. He became assistant manager of the land department in 1944.

Jimmie D. Harrington, who has been a research technologist at Magnolia field research laboratories, Dallas, Texas, has been transferred to the Kermit producing district and reclassified as a petroleum engineer.

Gerald S. Young, Jr., formerly petroleum engineer at the Oklahoma division offices in Oklahoma City, has been transferred to the West Texas division offices with headquarters at Midland, Texas.

Thomas B. Lowary, who has been petroleum engineer at the Duncan, Oklahoma, producing district office, has been moved to the Oklahoma division offices with headquarters at Oklahoma City.

D. Thomas Byrne of Bradford, Pennsylvania, has been appointed field engineer for the production research laboratory of the Pennsylvania Grade Crude Oil Association. A native of Connellsville, Pennsylvania, Byrne was graduated last year from the University of Pittsburgh, school of petroleum engineering. He has been a member of the engineering staff of the Quaker State Oil Refining Corporation in Bradford.

Ralph O. Rhoades has been appointed to the newly created position of executive assistant to the vice president on the staff of the production department in Pittsburgh, Pennsylvania for Gulf Oil Corporation. Rhoades received a B.A. degree in geology from Stanford University in 1922, and joined Gulf in 1926 as a geologist in South America. He served the company in the Middle and Far East and in Europe. In 1939 he was assigned to Gulf's London office. Rhoades was transferred to Pittsburgh in 1940 and rose from geologist to staff geologist and chief, land and exploration branch, before his newest appointment. His new duties will consist of aiding the vice president in any matter falling within the jurisdiction of the vice president. Effective with Rhoades' appointment, the title of staff geologist has been discontinued and **B. F. Hake** has been appointed chief of the land and exploration department.

T. C. Borland has been named assistant division production superintendent of Stanolind Oil and Gas Company's central division. He will replace **H. T. Hunter,** who has been transferred to the company's Tulsa general office.

Since 1948, Borland has been division engineer in Stanolind's Texas-Louisiana Gulf Coast Division at Houston, Texas. He joined Stanolind in 1935 following his graduation from Cornell University with a degree in mechanical engineering and, before entering the armed forces as a naval officer in 1942, had advanced to the position of field engineer.

Cecil V. Hagen, has been named president and general manager of Canada Southern Oils, Ltd., which will be organized in the near future as a subsidiary of Pancoastal Oil Company. He is former chief geologist for Superior Oil of California, and consulting geologist in Houston, Texas.

Gilbert P. Moore, Dallas consulting geologist, was recently named president of the Dallas Geological Society. Other officers are: **Wallace Ralston,** Sun Oil, vice president: **John C. Dunlap,** DeGolyer and MacNaughton, secretary-treasurer, and **Albert E. Oldham,** American Liberty Oil Company, executive committee.

Don Bills has been appointed acting district geologist in the Illinois Basin area for Cities Service Oil Company (Delaware), replacing **Ralph Hamblin** who resigned. The Cities Service district geological and land offices for the area are located in the Schultz Building in Olney, Illinois.

THE TURNAROUND

Petrochemicals

PETROCHEMICALS and special products derived from petroleum and natural gas by processes normally considered chemical are receiving an important boost at present, due only in part to the gathering of war clouds. While a large portion of this activity is centered in the southwest, a great deal of it is opening, or re-opening operations elsewhere.

Synthetic rubber and its components, ethylene, carbon black, and any number of other products are booming all over the petroleum-and-gas country. Goodyear is reactivating its copolymer plant at Akron, along with some partners. General Tire is taking over full operation of the Baytown, Texas (Humble suburb) rubber plant, General Latex having moved over with Goodyear. Copolymer Corporation is opening the 15,000-ton Esso Standard plant at Baton Rouge. Phillips Petroleum Company, pioneer and avid researcher in the whole rubber picture, takes over from U. S. Rubber the copolymer unit at Borger. U. S. Rubber is opening the enormous copolymer plant at Port Neches, Texas, next-door neighbor to the 100,000-ton butadiene plant there.

Polymer Corporation Ltd., of Sarnia, Ontario, is adding 6 new reactors to the 30 existing there making GR-S rubber, and is increasing its finished rubber capacity by about 50 per cent. Paralleling this, Imperial is expanding its facilities. A shortage of acrylonitrile, for the making of Buna N or so-called nitrile type (non-tire) rubbers appears to be inducing Dow at Sarnia to plunge into making the acrylonitrile. Dow is operating the government styrene plant near Los Angeles, but has laid aside its plans for a polystyrene plant in that area, due to rubber's demand for its second most important intermediate.

Phillips breaks into the news again, not long ago, with a "super abrasion" furnace black, SAF, which has properties more useful in rubber than that company's furnace black, Philblack A, now well known to the industry. The new black bids fair to improve flexcracking, treadwear, and other drawbacks to synthetic rubber. The Cabot interests are completing a huge furnace black plant at Big Spring, Texas, taking as raw material heavy cracking still residues from next-door neighbor Cosden Oil Corporation. Same company is reputedly planning another furnace black plant elsewhere.

In chemicals the synthetic fuel plant at Brownsville, Texas, building these five years or so, is reported on stream for test runs, as is its counterpart the Stanolind chemicals concentration unit alongside. Atlantic is building an alkyl aryl sulfonate unit at Port Arthur, Texas (detergents). Gulf is planning an ethylene unit at same address. A dozen other chemical units of sundry types by different companies are reported or rumored in various stages of discussion, planning, design, or construction, primarily along the Gulf Coast.—A.L.F.

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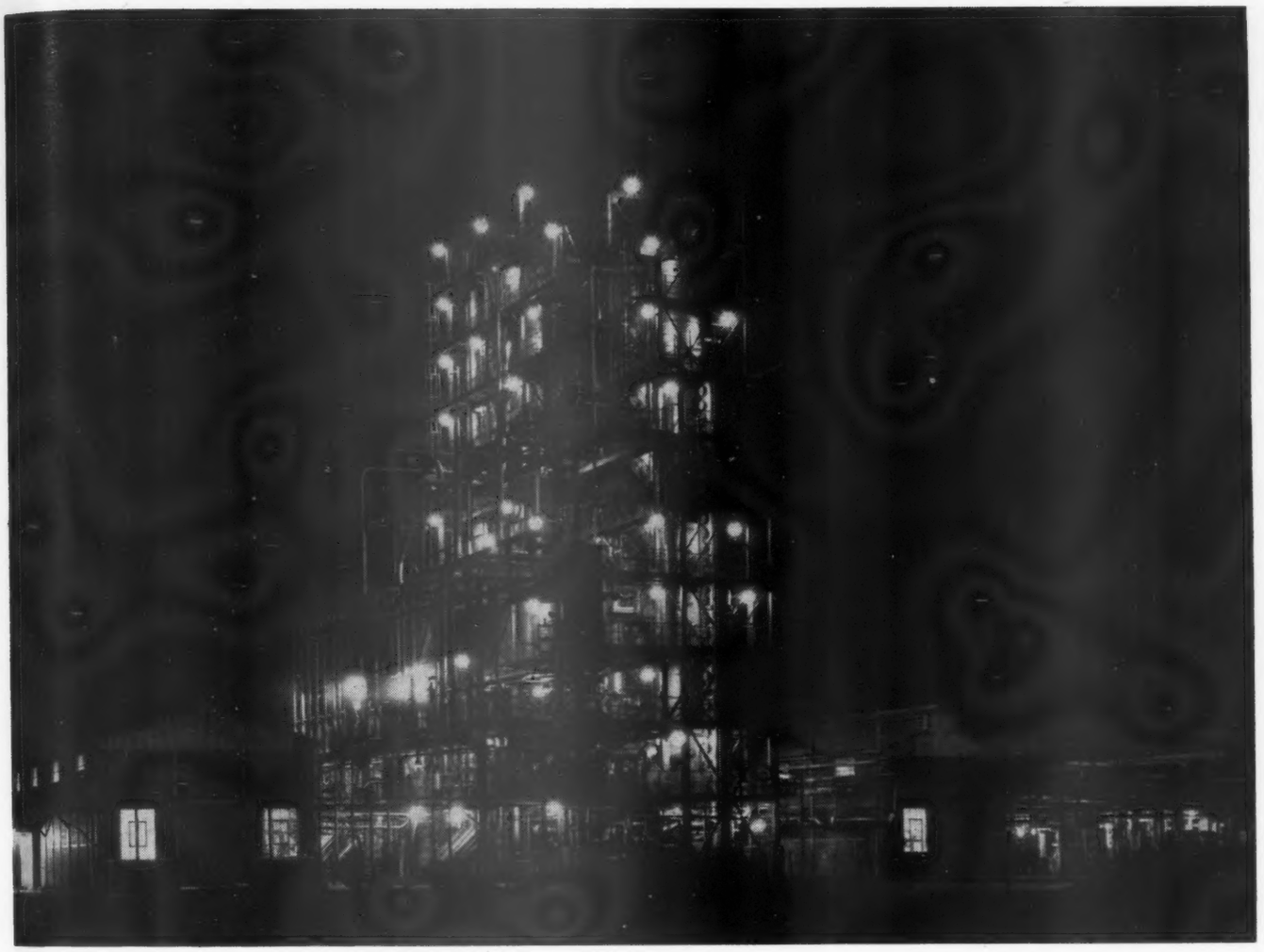

Night lights of new distillation unit at Shell's Stanlow refinery shine out over Ellesmere Port, England.

Shell's U. K. Refinery Program

V. S. SWAMINATHAN

THE Shell Haven and Stanlow extensions form part of the general refinery expansion program of the Royal Dutch-Shell group, which is designed to increase United Kingdom refining capacity from 2,500,000 to 19,500,000 long tons over the period 1947-53 at a total cost of about £125,000,000. This in itself is part of an overall European refinery expansion program scheduled to play an important role in plans for post-war economic and industrial recovery and progress. Whereas in the past it has normally been the practice of the oil industry to refine crude petroleum at source the recent trend to erect refineries in Europe had been caused by the circumstances in which the industry found itself at the end of the war. Five years ago Europe was an area that attracted companies to erect refineries because it offered political stability more than most areas in the old world, reasonable costs, ample labor, and the ancillary services associated with refineries. It was, moreover, an area in which these plans could be executed quickly.

At the end of the war Shell's refining facilities in the United Kingdom consisted of specialized plants at Shell Haven and Stanlow with topped crude capacities of 800,000 and 925,000 tons per annum respectively. In addition, there was a small asphalt plant at Ardrossan, Scotland, with a yearly capacity of 225,000 tons. In 1947 a refinery at Heysham, which Shell had acquired from the U.K. Government, was put into operation with a capacity of 1,500,000 tons per annum.

The Shell expansion program under way in Britain consists of extensions to existing installations at Shell Haven and Stanlow, which when completed in 1952-53, at an estimated cost of £25,000,000, will take the combined capacities of these two plants to a total of about 6,000,000 tons. With the addition of the Heysham plant (and excluding that at Ardrossan which is of a specialized type) Shell's

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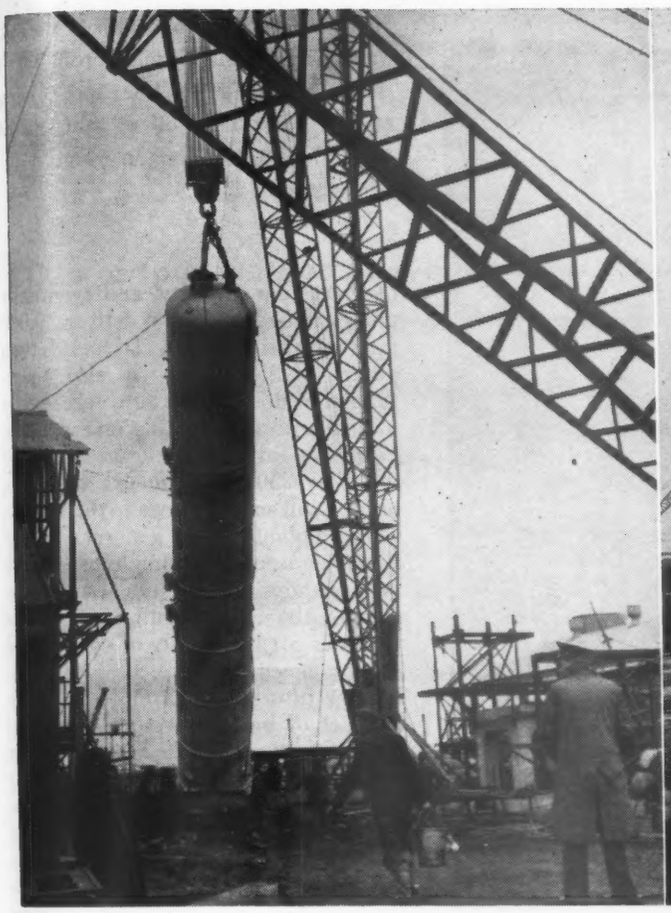
Shell began reconstruction of Heysham plant, Lancashire, in 1948. Photo shows fractionating equipment of No. 3 unit, compressor house, fractionating equipment of No. 2 unit, and in background, the I. C. I. Works.

Miners worked 50 ft under the Thames at Shell Haven, Essex, to build a tunnel to carry cooling water to refinery. In the photo miners are coming out of the entrance air lock after finishing an 8-hr shift in the pressurized tunnel.

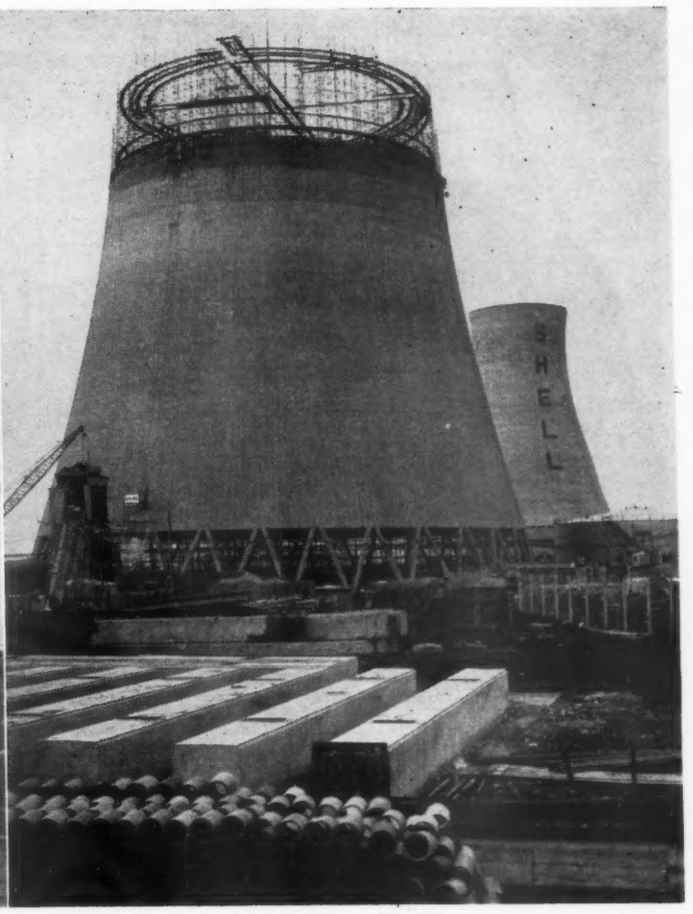
total refinery capacity in 1953 will be in the region of 7,500,000 tons a year, thus making the company by far the largest refinery operator in the U.K.

Good progress has already been made on the Shell Haven and Stanlow projects, which will produce gasoline, diesel oil, and fuel oils for the home market, and provide some of the specialized feedstocks previously imported. The location of both refineries is convenient for the distribution of petroleum products and derivatives by road, rail, or sea. Shell Haven is situated admirably on the banks of the Thames Estuary within easy access of London. Stanlow is situated in the industrial area of Ellesmere Port about four miles from the entrance to the Manchester ship canal, where a new berth is being constructed to accommodate two large tankers of the size of s.t.s. *Velutina* of 28,000 dwt. Both refineries will be among the most complete and modern in Europe, and will play a major part in the establishment of oil refining as a great national undertaking.

At Stanlow the new refinery commenced operations at the end of 1949, a month ahead of schedule, when the first distillation unit went on stream. The completed refinery will include another distillation unit, the latest type of catalytic cracking and reforming plants, a polymerization plant, units for final treatment of the various products and the tallest and largest water



At the Stanlow refinery up goes the largest fractionating column ever built in Britain for the home industry. The column weighs 115 tons and measures 84 ft in height by 10 ft 8 in. in diam.



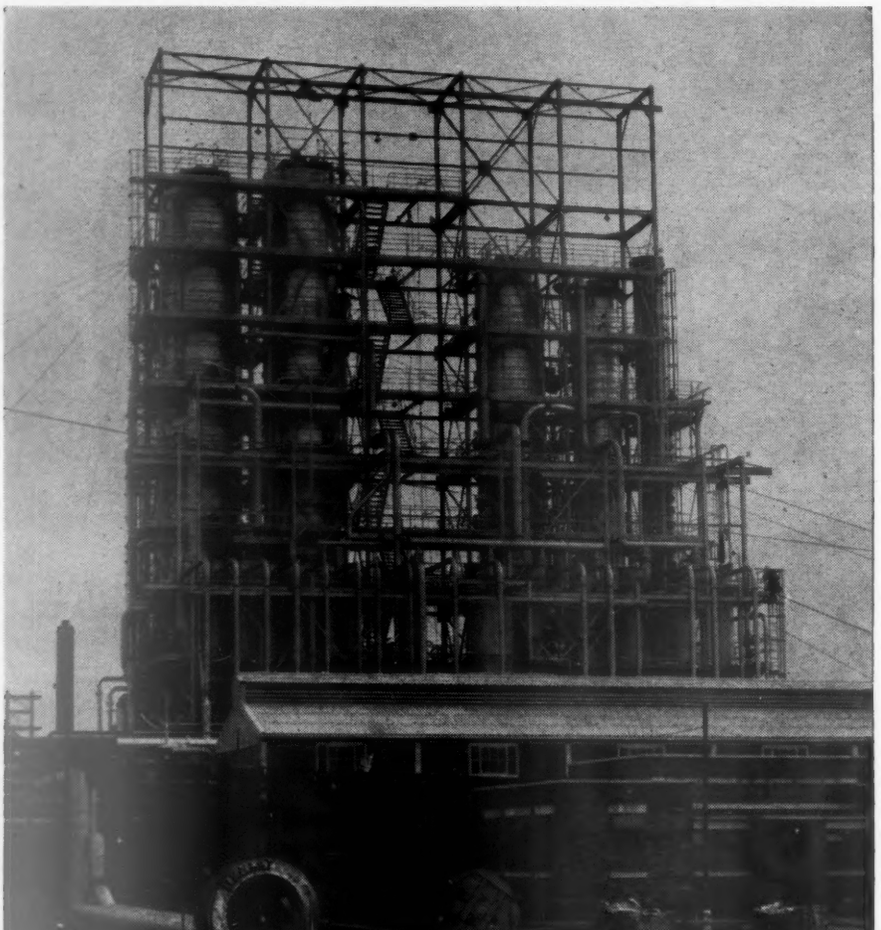
Said to be the world's largest, this cement cooling tower at Stanlow is 340 ft high and weighs 20,000 tons. The tower will handle 5,000,000 gal of water per hour.

cooling tower in the world. This concrete tower rising to a height of 341 ft 6 in., from ground level will dominate the site of Shell's new Stanlow refinery on the Manchester ship canal. It will deal with 5,000,000 gal of water an hour, which will be used for cooling purposes in the refinery processes. At its base the tower measures 272 ft diam, 168 ft at the neck and 177 ft at the top. More than 500 tons of reinforcing steel is being used in its construction and the total weight of the tower will exceed 20,000 tons. Since the new refinery began to operate last December—it is already handling crude at the rate of 1,000,000 tons a year—much interest has been aroused in Chester and the surrounding area, and Shell's new refinery bids fair to become a counter-attraction to the world-famous Illuminations at Blackpool.

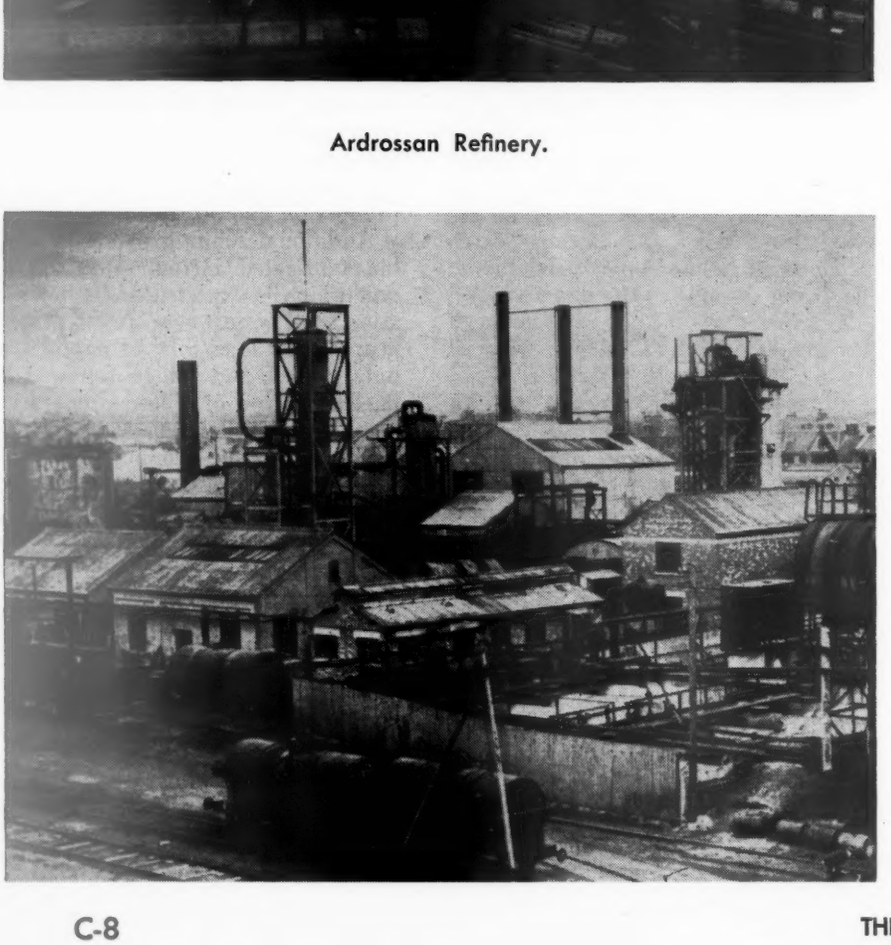
Over 2200 workers are busy on the construction of the Shell Haven refinery on the Thames-side. As it takes shape and more equipment is received the labor force will rise to 3000. Early this year a 900-ft long, 9-ft diam tunnel was being built by miners under the river to carry cooling water, which will be taken to a large pump house 30 ft below ground level. To provide domestic water for the housing site and the refinery an additional large diameter pipe line, some 30 miles long, is being installed. Developments on the refinery site include completion of more than 5 miles of concrete surfaced roads, together with 4½ miles of rail sidings and distributive rail lines to handle thousands of tons of construction material and plant equipment being delivered daily by road and rail.

The Shell Haven refinery is scheduled to start operations next November. The first distillation plant will process a designed intake of 6000 tons of crude oil per stream day. Notable features of this plant are the high degree of control by instrumentation; most of the operating pumping units will be electrically driven. Concurrent construction of a doctor treating plant will provide facilities for the treatment of approximately 1300 tons of straight-run gasoline from the distilling unit. Also included in the primary refinery plan is the installation of pump and weigh-house, fully equipped for intensive TEL blending of gasolines to the desired octane rating and production quantity required.

Additional refining plants now being fabricated include a reforming unit which is expected to be in operation by May next year. It will process nearly 1200 tons/S.D. of naphtha or light gas oil, and will be followed by the installation of a feed preparation plant having a design capacity of 2500 tons/S.D. for the production of bitumen feedstock, whose completion is scheduled for November, 1951. Heat exchange equipment to operate the above plants will be serviced by water obtained from an intake point in the River Thames and pumped to the process area off-takes through 9-ft diam subterranean concrete ducts. The used water returns through another duct into a large oil interceptor, thence being discharged into the river. The water pump house measures 250 ft by 50 ft with main pump units assembled 30 ft below ground level. These steam turbine-driven pumps are



Ardrossan Refinery.



First crude distillation plant to go into operation at the Stanlow refinery is shown at left. It has been processing Middle East crude oil at the rate of 1,000,000 tons a year.

of 2600 gpm capacity, and eventually units will be installed to deliver 80,000 gpm cooling water. Diesel-driven pumps of 2500 gpm will also be arranged in this pump house specifically to deal with fire fighting emergencies.

In the initial stages three 60,000 lb/hr by 250 psig Babcock & Wilcox boilers will supply steam to the various refinery plants and to general site auxiliary equipment, pumphouses, tank farms, shops, offices, etc. Layout design of the boiler plant incorporates facilities for the supply of compressed air for general service, besides allowing for future installation of a duplicate set of boilers as development of the refinery proceeds. Electric power for refinery operations is obtained by two main feeders branching from the local electrical authorities Tilbury and Raleigh 33 kva overhead systems to the refinery intake sub-station transformers, thus affording a twin-source supply with a standby insurance against possible failure of either center. Power supply of 6600 v from the intake station will proceed underground to localized sub-stations throughout the site, from which low tension 415 v will be distributed to the required consumer points. An efficient system of chemical treatment of raw water being essential, an elaborate complex of treating equipment, settling tanks, pumps, lines, etc., is being installed to insure adequate supplies of conditioned water to the boilers and other services. An aggregate of nearly 550,000 cu m of tankage is being arranged on the refinery site and adjacent tank farms for the handling of incoming crude oil, plant feed service, blending and product storage. New 14,000-ton capacity crude oil storage tanks are being erected and the entire scheme should be operating fully in November, 1951. Construction of refinery administrative, operational, laboratory and engineering offices, together with canteen facilities for refinery personnel are nearing completion. Extensive store houses, machine shops and auto repair shops have been in operation for some time to cater for the maintenance of construction equipment, transport, etc., including fabrication of the multitude of piping details required for the plants and interconnecting transfer pipe lines.

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Pressure Drop Calculation in Bubble Plate Columns

One of four methods developed for this purpose is discussed and required mathematical data are given

JU CHIN CHU

THE estimation of pressure drop of vapor flowing upward in a bubble plate distilling column is essential in the design and the operation of the latter. In vacuum distillation where the pressure in the still must be kept below a certain level to prevent possible thermal decomposition, a knowledge of the pressure drop across the plates predicts the necessary degree of vacuum to be maintained in the condenser. Minimum pressure drop through the column is usually desirable to assure low bottom pressure and temperature and the design of such special columns is possible only through an understanding of all factors affecting the pressure drop.

Excessive liquid and vapor loads during fractionation give rise to flooding which is the complete backup of the liquid in the column or even into the condenser. If the spacing between trays in the column is equal to the total liquid head in the downspouts, any slight increase in either liquid or vapor load will cause the liquid to fill up the vapor space and to cause flooding. To avoid this undesirable difficulty in operating a fractionating column, it is usually recommended to use tray space at least twice the total height of liquid in the downspouts. As the total height of liquid in the downspout is equivalent to pressure drop of vapor across the plate, plus weir height, liquid head above the weir and the hydraulic gradient across the plate, the calculation of pressure drop is indispensable in fixing the tray spacing in the design.

When the vapor passing through a bubble plate is about evenly distributed throughout all the bubble caps, the plate is said to be stable. The problem of plate stability is more critical in large columns, the increasing number of which have been installed and operated since World War II. A criterion of plate stability is the vapor distribution ratio, which is the ratio of the liquid gradient to the pressure drop of the vapor passing through the caps calculated as if no liquid gradient were present. A plate is considered as stable if the vapor distribution ratio is less than 0.7. If the liquid gradient is high enough, liquid will actually run down through bubble caps in the upstream portion of the plate. This phenomenon, which is referred to as "dumping", materially cuts down the active area of the plate and gives poor plate efficiency. To prevent liquid "dumping" through the bubble caps, there must be a sufficient amount of vapor flowing through its risers to create a pressure drop giving vapor distribution ratio below 0.7. Through the calculation of pressure drop, it is thus possible to find out the proper diameter of the column, number of bubble caps, height of risers, etc., to be used in designing a column with stable plates, so that the available amount of vapor flowing to the plate is sufficient to push the liquid flowing across the plate into the space above bubble caps. This gives a thorough contact between liquid and vapor, thus insuring a high plate efficiency.

It is a frequent practice that the distilling columns in the plant are operated in services for which they were not designed originally. A knowledge of pressure drop evaluation is valuable to chemical engineers in deciding whether adaptation to new service is possible in the light of plate stability limitations.

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Methods of Pressure Drop Calculation

To date there are 4 methods available for the computation of pressure drop through a bubble plate; i.e.

(1) Rogers and Thiele's
(2) Kirkbride's
(3) Dauphine's
(4) Eld's

These four methods are described in order in the following paragraphs. The comparison of their calculated results will be presented in the next section.

(1) *Rogers and Thiele.*

The first method for estimating the pressure drop of a vapor flowing through a bubble cap was contributed by Rogers and Thiele.[7] They gave an analysis of the components of the pressure drop, especially of bubble caps having teeth, slots or similar devices along the lower edge. The total pressure drop through a plate consists of three parts; i.e.

(1) pressure drop through the riser and annular space
(2) pressure drop through slot opening
(3) pressure drop due to the difference of liquid head between the inside and outside of the bubble cap.

Fig. 1 is a diagrammatic cross section of a bubble cap in action. Vapors are arising through the opening A and bubbling through the liquid at the slot B-C. The pressure drop through the riser and annular space (between A and B) is assumed to be negligible in comparison with the others. The pressure at B′, just outside the slot, is the same as at B, the surface of the liquid under the cap. Since the two points are at the same liquid level, and the driving force of blowing the vapor is equal to zero, there will be no bubbling under this level. At a higher point, as C, the pressure of vapor inside is greater than that of the liquid

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outside by the liquid height, (B-C), which is the driving force to bubble liquid outward. The pressure drop across the plate is equal to the difference in liquid height on the inside and outside of the cap, plus the pressure drop through the slot B-C under the cap. The height of liquid under the cap is known when the tooth opening is given. If the vapor is forced through a cap with a given submergence above the top of the slot to produce no splashing, the head represented by the static submergence above the notch will be equal to the liquid head. On the other hand, if the flow of vapor gives a steady condition of splashing, a certain number of liquid droplets is fluidized in the space above the cap. Because the same amount of liquid is present as when no vapors were flowing, the static head should remain the same as before. In actual cases, a weir is present on the plate to govern the rate of overflow which is directly proportional to $h^{3/2}$ where h is the head of flowing fluid. On a plate where continuous foam is present over the weir, the rate of overflow is determined by the density of the foam as well as its height. As the density of the foam is inversely proportional to the height to which it rises, and the rate of overflow to the next plate is proportional to the 3/2 power of the height, there must be a decrease in static head to such extent that a weight flow of foam equivalent to the weight of the liquid entering the plate. The exact pressure drop is therefore a complicated function of height of foam produced, the proximity of the overflow weir to the bubble caps and the height of weir relative to the slots of the cap.

If the weirs were far removed from the splashing, the pressure drop through the bubble plate is represented by a head of the liquid equal to the height in the quiet portions of the plate, minus the height under the caps, plus the head drop through the slots. The pressure drop through the slots increases as the vapor velocity rises by the amount of increase in the slot opening.

Theoretical Derivation of Equations for Slot Pressure Drop

Triangular shaped slots: With reference to the diagram of triangular slots of maximum slot opening equal to "h" inches in Fig. 1, consider a shaded "dh_a" at height "h_a" inches from the bottom. If the local linear velocity through the section dha is represented by U, the application of Bernoulli's equation to the vapor flowing through that section in the slot, yields

$$U = C\sqrt{2g\left(\frac{h_a}{12}\right)\left(\frac{\rho_L - \rho_v}{\rho_v}\right)} \quad (1)$$

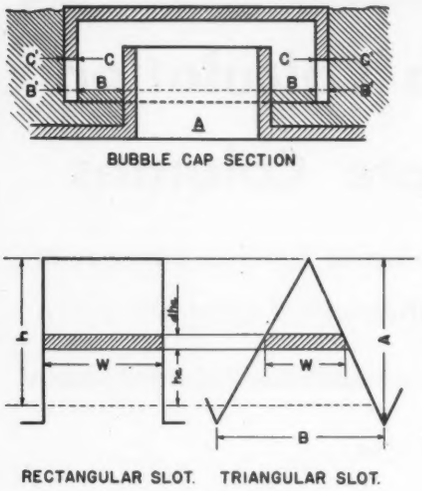

FIG. 1. Cross-section of bubble cap in action.

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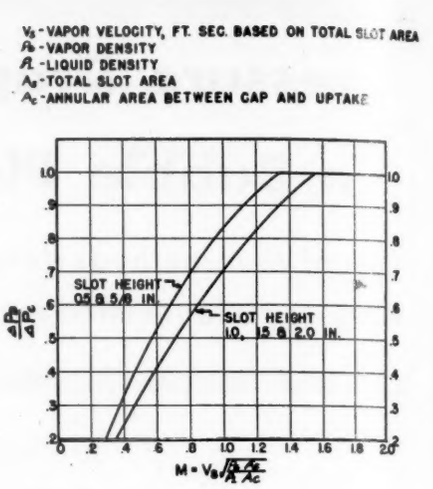
V_s - VAPOR VELOCITY, FT. SEC. BASED ON TOTAL SLOT AREA
ρ_v - VAPOR DENSITY
ρ_L - LIQUID DENSITY
A_s - TOTAL SLOT AREA
A_c - ANNULAR AREA BETWEEN CAP AND UPTAKE
SLOT HEIGHT 0.5 & 5/8 IN.
SLOT HEIGHT 1.0, 1.5 & 2.0 IN.
$M = V_s\sqrt{\frac{\rho_v}{\rho_L}\frac{A_s}{A_c}}$

FIG. 2. Ratio of pressure drop through dry cap to that for liquid on the tray up to the top of the slots.

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where

ρ_L = density of liquid, ρ_v = density of vapor } lb/ft³

C = orifice coefficient

12 = conversion factor from inches to feet

The volume of vapor flowing through "dh" section in cu ft = $d V_s = U (W\ dh_a$ . . . . . (2)

where W is the width in inches of slot at the section dh_a, and is related to the width of the slot at the base, B, in inches through the following relation of the proportionality:

$$W = \frac{(h\text{-}h_a)\ B}{144\ A} \quad . \quad . \quad . \quad . \quad (3)$$

where h is slot opening in inches.

Subs. Eq. (1) and (3) into (2), one obtains

$$dV_s = C\sqrt{2g\left(\frac{h_a}{12}\right)\frac{\rho_L - \rho_v}{\rho_v}\left(\frac{h\text{-}h_a}{144}\right)}\ \frac{B}{A}\,dh_a \quad . \quad . \quad . \quad (4)$$

Integrating Eq. (4) over the entire slot, the following expression for the total volume of vapor flowing through one slot is obtained:

$$V_s = \frac{C\ B}{144\ A}\sqrt{\frac{2g}{12}\frac{(\rho_L - \rho_v)}{\rho_v}}\left[\int_o^h h\ h_a^{1/2}\,dh_a + \int_o^h h_a^{3/2}\,dh_a\right]$$

$$= (c)\frac{B}{2A}(0.00\ 1068)\ \frac{2g\ (\rho_L - \rho_v)}{\rho_v}\ h^{5/2} \quad . \quad (5)$$

If the number of slots per cap is represented by N, the volume of vapor flowing per cap is equal to V_sN.

The relation for rectangular shaped slots can be derived similarly, giving

$$V_s = (C)\ (W)\ (0.00\ 134)\sqrt{2g\frac{(\rho_L - \rho_v)}{\rho_v}}\ h^{3/2} \quad . \quad (6)$$

where W = width of the rectangular slot, inches.

Rogers and Thiele[7] conducted the experiments by passing air through the triangular slots into water and also into naphtha at various velocities and with various heights of liquid above the top of the notch. Hydrogen and carbon dioxide were passed through the slots to determine the effect of the change of gas on the performance of the slots. Their experimental results with triangular slots are correlated by the following equations:

(1) Air into naphtha
$V_s = (0.51)\ (0.067)\ h^{5/2}$ . . . . . (7)

(2) Air into water
$V_s = (0.51)\ (0.078)\ h^{7/4}$ . . . . . (8)

(3) Hydrogen into water
$V_s = (0.51)\ (0.292)\ h^{7/4}$ . . . . . (9)

(4) Carbon dioxide into water
$V_s = (0.51)\ (0.0624)\ h^{7/4}$ . . . . . (10)

Thus it is seen that with an orifice coefficient of 0.51, the experimental results show fair agreement with the equation derived for pressure drop through slots of the bubble caps.

To study a practical case, Rogers and Thiele[7] passed air through a model bubble cap immersed in water. The cup contained 54 triangular slots, 1.25 inches high by 0.625 inch at the base. It was indicated by experimental

results that a small but distinct lowering of the static liquid level in the channel with increased air flow did occur. This confirms their theoretical deduction that the static head over the top of slots might actually decrease as the vapor flow through the cap causes a foam to build up over the overflow weir.

Rogers and Thiele's method can be summarized by saying that:
pressure drop through a bubble plate = pressure drop through the chimney uptake and annular space + pressure drop through slots as calculated by Eq. (5) or (6) + static liquid head above the slots. The first component pressure drop is negligible. However, Bolles[2] pointed out that this pressure drop, although small, is not negligible and can be calculated by the following equation:

$$h_{rc} = 0.512\ (V_v)^2 \frac{\rho_v}{\rho_L}. \quad . \quad (11)$$

where V_v is the linear velocity of vapor through the riser and h_{rc} is the head equivalent to the pressure drop through the riser and annular space.

The static head above the slot is a maximum at zero rate of vapor flow. If the splashing occurs during the flow of vapor around the bubble caps which are close to the weir, the static head may decrease with the increased vapor flow. Since the actual decrease of static head due to the formation of foam during the splashing has not been predictable, the quiescent static head is used for the calculation of pressure drop and therefore Rogers and Thiele's treatment probably yields maximum values.

(2) *Kirkbride.*

Kirkbride[5] gave the following formula to calculate the pressure drop through riser and bubble cap:

$$h_c = V_r^2 \frac{\rho_v}{\rho_L} \quad . \quad . \quad . \quad . \quad (12)$$

This, when added to the static head above the slots, gives the head equivalent to pressure drop through a bubble plate. Without giving any theoretical basis, Kirkbride's equation appears to give proper order of magnitude for the normal vapor flow encountered.

(3) *Eld.*

The calculation of pressure drop across a bubble plate according to Eld[4] may be followed in two separate steps:

1. Flowing of vapor through risers and caps.
2. Flowing of vapor through foam and mist in the space between the plates.

The first component pressure drop is computed as if the cap and plate are dry. This pressure drop must be equal to the friction loss through the straight passages plus the possible expansions and contractions when the vapor flows through the riser and cap. The frictional loss through the straight passages is negligible because of the short length. Since the standard bubble cap is designed so that the vapor velocity continuously decreases as it flows through the riser and cap, the only possible pressure drop of the vapor flowing through a dry cap and riser is that of expansion and can be represented by $K_v \frac{V_r^2}{2g} \rho_v$ where K_v is a constant characteristic of the cap design and varies with the proportion areas through the cap: riser, annular, slot and disengaging areas.

The pressure drop due to foam and mist above the plate was considered[4] as a function of the amount, density, and distribution of liquid charged to the plate. It is computed as equivalent to the height of liquid above the weir plus one-half of liquid gradient based on the volume and density of liquid entering the plate in the absence of vapor flow, giving

$$h_l = K_l \rho_L \left(h_l + \frac{1}{2} h_g\right) \quad . \quad . \quad (13)$$

where

h_l = pressure drop due to vapors flowing through mist and foam
h_l = liquid height above the weir, in.
h_g = liquid gradient across plate, in.
K_l = constant

Eld[4] conducted the tests on a glass fractionating column of 18 inches in diameter, using air as vapor and water as liquid. The column was equipped with 13 cast bubble caps of 2⅞ in. outside diameter arranged in three rows. The dimensions of the caps used in the test are listed in Table 1.

The experimental tests of Eld gave:

$$\frac{K_v}{2g} = 0.035$$
$$K_l = 2.81$$

Therefore, the total pressure drop across a bubble plate

$$= 2.81\ [h_l + (1/2)\ h_g]\ \rho_L + 0.035\ V_r^2\ \rho_v \quad . \quad . \quad . \quad (14)$$

(4) *Dauphine.*

The method of calculating pressure drop by Dauphine[3] consists of the following three steps:

1. Calculate total pressure through a dry bubble cap. This total pressure drop was arbitrarily divided into three components: i.e., uptake pressure drop, reversal pressure drop, and slot pressure drop. Uptake pressure drop is one through the riser; reversal pressure drop is the pressure difference between the top of the riser and the bottom of the annular space; slot pressure drop is one through the slot. The equations used for evaluating these three pressure drops have been evaluated from extensive experimental tests.

2. Determine the pressure drop with liquid just covering the slots from the dry cap pressure drop calculated in step 1, by the graphical correlation based on the experimental data of Mayer and Schneider[6, 8] using air through single caps, both dry and submerged.

3. Add the liquid head above the top of the slots to the pressure drop of wet cap calculated in step 2 to obtain the total pressure drop through a bubble plate of submerged caps.

To study pressure drop, both total and component, of air flowing through a single dry cap, Dauphine[3] used the bubble caps of 3 in., 4.22 in. and 6 in. in diameter. For each cap of a given diameter, three separate riser diameters were used, giving a cross-sectional area about ¼, ½, and ¾ of cap cross-sectional area. For each height of the riser, riser heights of 1⅔ in., 2½ in., 3½ in. and 5½ in. were used. For each arrangement of the riser and cap, air flow was varied over its maximum range with slot heights of 2 in., 1 in. and 0.5 in. The distance between the top of the riser and the top of the cap was also varied from ¼ in. to 2 in. by changing the cap height during the measurement of pressure drop.

The analyses of the data on component pressure drop from all different cap combinations[3] led to the development of the correlation for each of three separate component pressure drops through a dry cap.

The uptake pressure drop is independent of riser height in the range studied, but directly related to the diameter of riser. As long as reversal area, which is defined as the cylindrical area projected to the cap top by the riser, is equal to or larger than riser cross-sectional area, it has no effect on the uptake pressure drop. On the other hand, if reversal area is smaller than the cross-sectional area of the riser, the uptake pressure drop

TABLE 1. Dimensions of the tested bubble caps.

Type	Cast	Cast	Cast	Plate	Cast
Cap size, in.	2⅞ diam	5½ hex.	6½ hex.	6½ hex.	6 diam
Riser size, in.	1.61 diam	3⅛ hex.	3⅝ hex.	4½ diam	2.9 diam
Riser area, sq in.	2.04	8.45	11.37	15.90	6.61
Annular area, sq in.	2.57	8.65	14.60	17.37	6.90
Slot area, sq in.	3.24	10.92	22.00	21.94	10.20
Disengaging area between caps, sq in.	2.66	13.25	18.83	18.83	23.74

will be an inverse function of the square root of the ratio of reversal to riser area. For all cases where the reversal area is equal to or greater than the cross-sectional area of the riser, the uptake pressure drop can be correlated by the following expression (3):

$$h_u = 0.0183\ D_u\ (\sqrt{\rho_G}\ V_r)^{2.14} \quad \ldots\ldots\ldots\ (15)$$

where D_u is the inside diameter of the riser in inches.

For cases where reversal area is smaller than the cross-sectional area of the riser, the uptake pressure drop is given by (3):

$$h_u = \frac{0.0183\ D_u\ (\sqrt{\rho_G}\ V_r)^{2.14}}{\sqrt{\frac{A_r}{A_u}}} \quad \ldots\ldots\ldots\ (16)$$

where A_r is the reversal area and A_u is the inside cross-sectional area of the riser.

Reversal pressure drop was found independent of the changes in riser height, if the latter is greater than two inches. It is a complicated power function of the ratio of riser cross-sectional area to the reversal area and vapor velocity. The function seems discontinuous, dropping out at different values of the ratios of area. Reversal pressure drop increases with the decrease of reversal area until the point where the vapor flow from the riser contracts. When riser cross-sectional area is increased in a given cap to give flow contraction in the annular space, reversal pressure drop is increased. The data on reversed pressure drop for riser heights of 2.6 in., 3.5 in. and 5.5 in. was correlated empirically by (3):

$$h_r = 0.0097 \sqrt{\rho_G}\ \frac{V_r^2\ A_u^{21.74}}{A_m\ A_c} \quad \ldots\ldots\ldots\ (17)$$

where A_c is the inside effective cross-sectional area of the cap and A_m the smaller of the two areas, reversal and annular area.

For the riser height of 1.6 in. and slot heights of ½ in. and 1 in., the reversal pressure drop is represented by (3):

$$h_r = 0.0167 \left[\sqrt{\rho_G}\ V_r\ \frac{2A_u^2}{A_m\ A_c}\right]^{1.74} \quad \ldots\ldots\ldots\ (18)$$

The slot pressure was found (3) independent of reversal area; riser height in a given cap if the slot height is less than riser height; and the diameter of the riser if the uptake area is not greater than half of the cross-sectional area of the cap. Slot pressure drop is a definite function of cap diameter and the vapor velocity through the slot. At a given flow rate of vapor through the slot, the slot pressure drop changes directly with the diameter of the cap.

For a normal cap of good design with the uptake area not greater than half of cap area, and riser height greater than 1.6 in., the measured slot pressure drop can be correlated by the following equation (3):

$$h_s = 0.0216\ [\sqrt{\rho_G\ D_c}\ \ V_s]^{1.74} \quad \ldots\ldots\ldots\ (19)$$

where h_s is the slot pressure drop in inches of water, and D_c the inside diameter of the cap in feet.

The slot pressure drop measured by Dauphine[3] represents two pressure losses; i.e., the energy loss due to the change of direction at right angle of the vapor before entering the slots, and a static pressure change of the vapor flowing through the slot. It is therefore impossible to correlate slot pressure drop simply on the basis of the orifice equation.

Thus it is seen that the equation (15) or (16) is used to calculate the uptake pressure drop; the equation (17) or (18) to compute the reversal pressure drop; and the equation (19) to determine the slot pressure drop. When these three pressure drops are added together, the total pressure drop through a dry cap is obtained.

The effects of liquid on the plate were determined by a relation obtained from the work of Meyer[6] and Schneider.[8] They[6, 8] carried out the measurement of slot pressure drop and the sum of the uptake and reversal pressure drop in a one-foot column with single caps of commercial cast iron or copper ranging in diameter from 3, 4, and 6 in. A 6 in. galvanized iron cap was also used for the adjustment of slot height to as high as 2 in. With several liquids of different specific gravity, ranging from 0.878 to 1.6, and viscosity from 0.9 to 600 centipoises on the plate, air was blown through the caps and the pressure drops were measured. For all cases, the skirt of the bubble cap rests on the plate.

The experimental measurements have indicated that:

1. Slot pressure drop is less than the sum of reversal and uptake pressure drop on a wet plate.
2. Liquid head above the top of the slots gives only additive effects on the total pressure drop.
3. It is slot pressure drop, not reversal and uptake pressure drop, that is affected by the presence of liquid on the plate.
4. Primary factor affecting the ratio of dry to wet pressure drop is the vapor velocity through the slots.
5. Liquid viscosity in the range of 1 to 600 centipoises has no effect on the pressure drop of wet cap.
6. When the slot is kept completely open at sufficiently high slot velocity, the pressure drop of wet cap becomes identical to that of a dry cap.
7. The ratio of density of vapor to liquid and that of slot area to annular area are other important factors affecting the ratio of dry to wet cap pressure drop.

Analyses of all experimental data in the light of the above facts yield the graphical correlation (3) presented in Fig. 2 in which the ratio of dry to wet cap pressure drop is plotted against the group $V_s \sqrt{\frac{\rho_G\ A_s}{\rho_L\ A_c}}$, where A_s is the total slot area, while A_c the annular area between cap and the riser. Two different curves are presented, one for a slot height of 1 in. or greater, and the other for slots of small height as ½ or ⅝ in. This graphical relation can be used to determine the wet cap pressure drop with liquid just covering the slots from the total dry cap pressure drop calculated by the procedure mentioned previously. It might be pointed out here that the graphical relation applies to the case when equal areas for flow exist under the cap and the cap skirt rests on the plate.

Several complications arise when Dauphine's method (3) is applied to the practical design. First, if a clearance exists between the plate and the cap skirt, there is uncertainty about slot area used for the pressure drop calculation. If the values of the group $V_s \sqrt{\frac{\rho_G\ A_s}{\rho_L\ A_c}}$ is less than 1.55 for slots higher than 1 in. or less than 1.38 for ½-in. slots, vapor does not flow underneath the skirt of the cap, and it is reasonable to recommend that only the area between the cap teeth be used in computing total slot area and open slot velocity. To determine the velocity of vapor flow just to completely open the slots where skirt clearance exists, a correction factor of 0.9 is used to multiply the vapor rate calculated for the case of no skirt clearance. This approximates the use of 80 per cent slot opening with zero skirt clearance for the calculation of vapor rate to open the slots with definite clearance.

In a fractionating column the variations in vapor and liquid traffic, temperature, vapor and liquid density, exist from plate to plate. To find the pressure drop for the whole column, the exact method is to evaluate the pressure drop for each plate and to compute their summation. Normally, the use of average plate condition can

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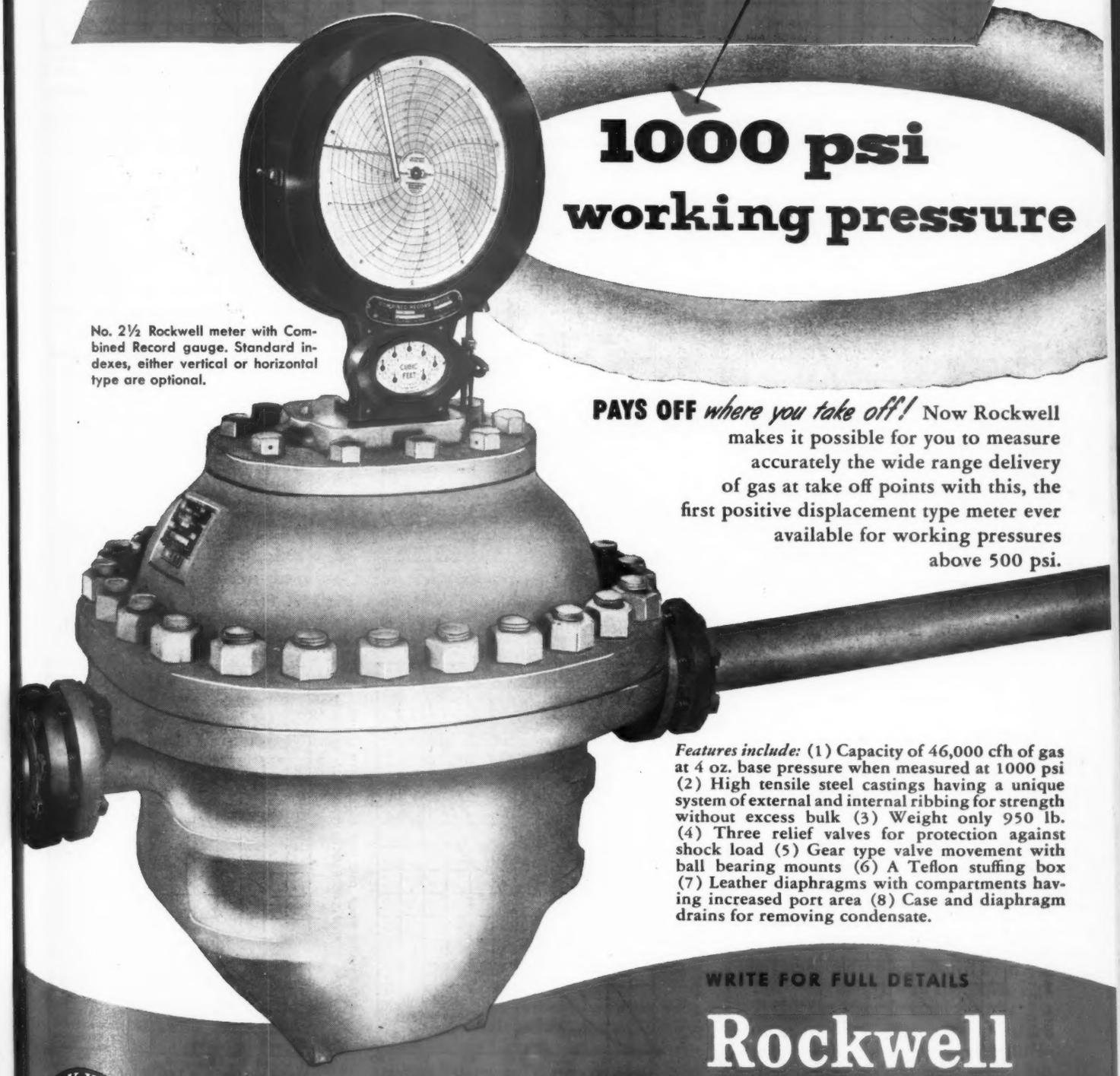

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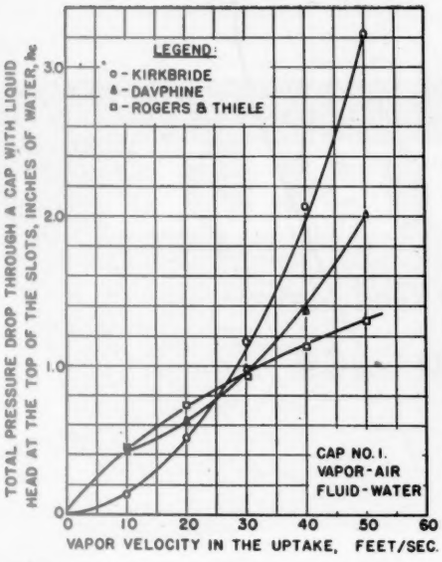
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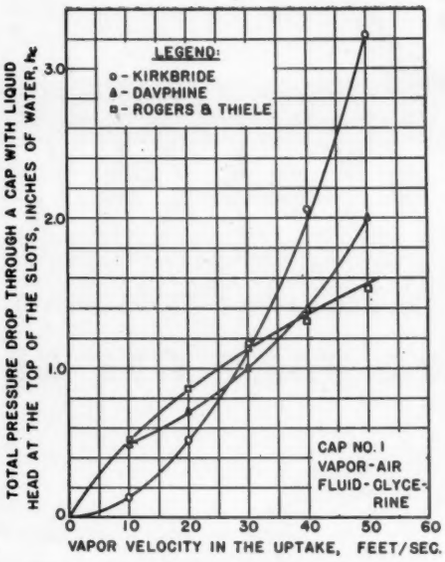
FLUID-WATER
TOTAL PRESSURE DROP THROUGH A CAP WITH LIQUID HEAD AT THE TOP OF THE SLOTS, INCHES OF WATER, hc
VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 3. Pressure drop through wet cap vs. vapor velocity through the uptake.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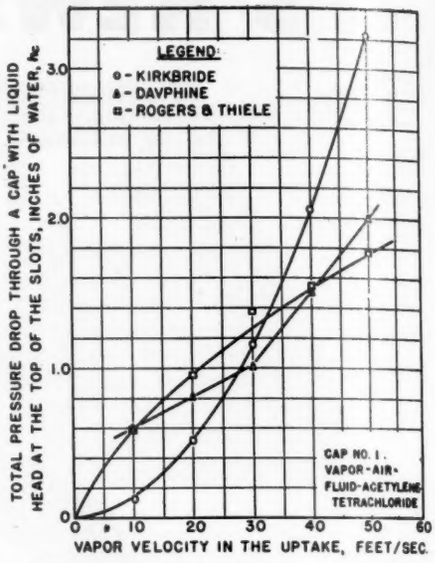
TOTAL PRESSURE DROP THROUGH A CAP WITH LIQUID HEAD AT THE TOP OF THE SLOTS, INCHES OF WATER, hc
VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 4. Pressure drop through wet cap vs. vapor velocity through the uptake.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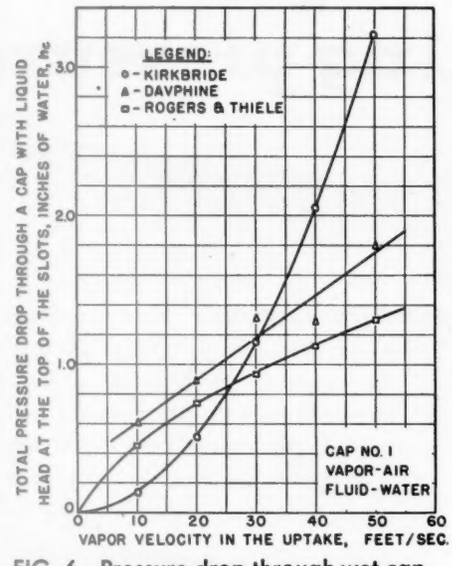
Δ - DAVPHINE
□ - ROGERS & THIELE
CAP NO. I.
VAPOR-AIR-
FLUID-ACETYLENE
TETRACHLORIDE
TOTAL PRESSURE DROP THROUGH A CAP WITH LIQUID HEAD AT THE TOP OF THE SLOTS, INCHES OF WATER, hc
VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 5. Pressure drop through wet cap vs. velocity through the uptake.


LEGEND:
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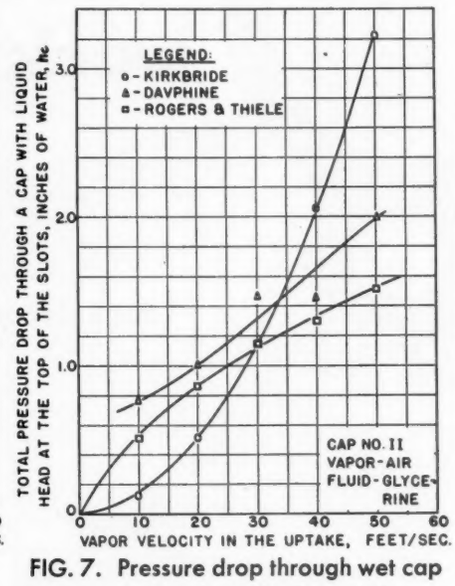
□ - ROGERS & THIELE
CAP NO. I
VAPOR-AIR
FLUID-WATER
TOTAL PRESSURE DROP THROUGH A CAP WITH LIQUID HEAD AT THE TOP OF THE SLOTS, INCHES OF WATER, hc
VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 6. Pressure drop through wet cap vs. velocity through the uptake.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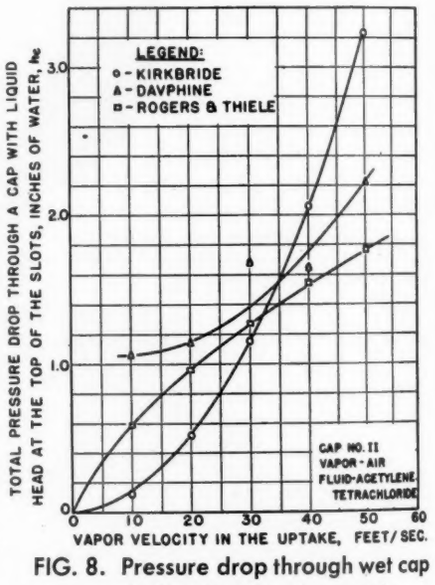
VAPOR-AIR
FLUID-GLYCERINE
TOTAL PRESSURE DROP THROUGH A CAP WITH LIQUID HEAD AT THE TOP OF THE SLOTS, INCHES OF WATER, hc
VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 7. Pressure drop through wet cap vs. velocity through the uptake.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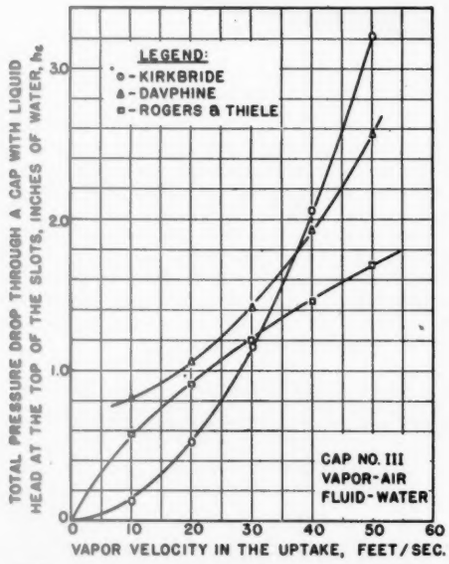
VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 8. Pressure drop through wet cap vs. velocity through the uptake.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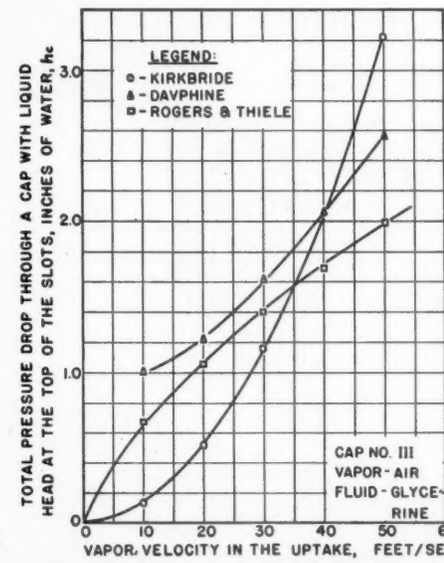
FLUID-WATER
TOTAL PRESSURE DROP THROUGH A CAP WITH LIQUID HEAD AT THE TOP OF THE SLOTS, INCHES OF WATER, hc
VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 9. Pressure drop through wet cap vs. velocity through the uptake.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CAP NO. III
VAPOR-AIR
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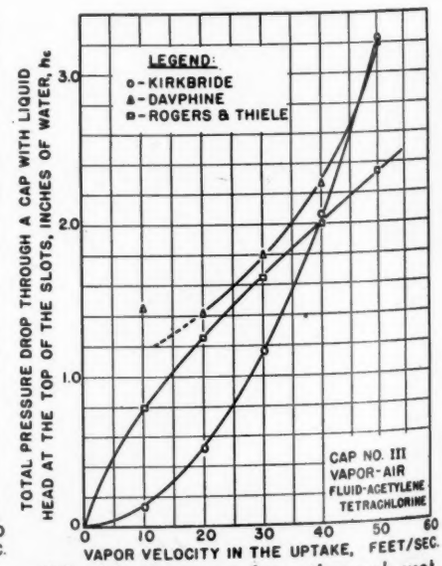
TOTAL PRESSURE DROP THROUGH A CAP WITH LIQUID HEAD AT THE TOP OF THE SLOTS, INCHES OF WATER, hc
VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 10. Pressure drop through wet cap vs. velocity through the uptake.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VAPOR VELOCITY IN THE UPTAKE, FEET/SEC.

FIG. 11. Pressure drop through wet cap vs. velocity through the uptake.

TABLE 2. Dimensions of standard bubble cap.

Cap No.	1	2	3
Cap diameter, inch		3	4
Number of slots	38	38	33
Slot area, sq in.	2.97	4.75	7.75
Approx. riser area, sq in.	3.1	3.1	6.0
Annular area, sq in.	3.1	3.1	6.0
Slot dimensions, inch	⅛ x ⅝	⅛ x 1	⅛ x 1¼
Riser diameter, ft	0.0827	0.0827	0.115

give fairly good results for the overall pressure drop in the column.

The presence of liquid gradient causes the uneven distribution of vapor flow and liquid head on each cap. This inequality becomes more pronounced in large columns. However, it is usually within the limit of calculation to use average vapor flow per cap and the static seal plus the weir head plus half of the liquid gradient as the cap submerges in evaluating pressure drop across a mutiple cap plate.

With the extensive data on total pressure drop through 540 differently constructed caps, Dauphine noticed[3] some interesting conclusions with regard to the best construction of caps for minimum pressure drop:

1. The minimum total pressure drop is obtained at a given air flow with uptake area equal to annular area, or to one-half cross-sectional area of the cap.

2. Total pressure drop is increased rapidly by any decrease in reversal area to less than one-half cross-sectional area of the cap, and unaffected by increase in reversal area to more than one-half cross-sectional area of the cap. For minimum pressure drop, a cap of good design has reversal area at least equal to one-half of the cross-sectional area of the cap, preferably greater when fouling could decrease the reversal area.

3. Pressure drop is unaffected by riser height for the 6 in. cap. When the short 1.6 in. riser is used for 4.22 and 3.0 in. cap, a definite increase in total pressure drop was noticed. With slot height of 2 in., which was higher than the riser, no change of pressure drop was observed. This is presumably due to the flowing of vapor horizontally from the riser to slots without usual complete reversal plus 90 deg change in direction before entering the slots. For minimum pressure drop it is recommended to use riser at least 2½ in. high, especially with smaller caps which have greater turbulent loss caused by the short riser.

The comparison of the calculated pressure drop with some measured ones[3] indicated fairly good agreement. The expected accuracy of Dauphine's correlation is about ± 20 per cent for columns operating at atmospheric or higher pressures. In vacuum distillation, the accuracy may be less, as a large percentage error will be resulted from a small absolute error.

TABLE 3. Calculation of pressure drop through a bubble cap by Dauphine's method.

Cap No.	Vu	Vs	hu	hr	hs	hD	M	Liquid phase: Water hD/hc	Water hc	Water M	Glycerine hD/hc	Glycerine hc	Glycerine M	Acetylene tetrachloride hD/hc	Acetylene tetrachloride hc
1	10	10.13	0.01412	0.0595	0.0402	0.114	0.355	0.272	0.419	0.316	0.23	0.495	0.28	0.19	0.60
	20	20.26	0.0625	0.199	0.126	0.388	0.71	0.62	0.627	0.63	0.55	0.71	0.56	0.48	0.81
	30	30.39	0.148	0.402	0.266	0.816	1.06	0.833	0.978	0.95	0.80	1.02	0.84	0.75	1.09
	40	40.52	0.212	0.65	0.441	1.36	1.42	1.	1.36	1.27	0.97	1.40	1.12	0.90	1.51
	50	50.65	0.408	0.99	0.648	2.05	1.77	1.	2.05	1.58	1	2.05	1.40	1.	2.05
2	10	6.35	0.01412	0.0595	0.0111	0.085	0.282	0.14	0.607	0.25	0.11	0.77	0.223	0.08	1.06
	20	12.70	0.0625	0.199	0.0595	0.321	0.565	0.465	0.883	0.504	0.32	1.01	0.445	0.28	1.15
	30	19.05	0.148	0.402	0.23	0.773	0.848	0.39	1.313	0.755	0.53	1.46	0.67	0.46	1.68
	40	25.40	0.272	0.65	0.144	1.02	1.15	0.79	1.295	1.00	0.7	1.46	0.89	0.62	1.65
	50	31.75	0.408	0.99	0.292	1.69	1.41	0.94	1.80	1.25	0.85	1.99	1.11	0.76	2.22
3	10	7.74	0.0196	0.0596	0.0514	0.131	0.315	0.16	0.816	0.28	0.13	1.01	0.234	0.09	1.45
	20	15.48	0.086	0.202	0.163	0.451	0.629	0.42	1.07	0.56	0.37	1.22	0.50	0.32	1.41
	30	23.22	0.206	0.406	0.325	0.937	0.945	0.66	1.42	0.84	0.58	1.62	0.75	0.52	1.80
	40	30.96	0.378	0.664	0.550	1.59	1.21	0.825	1.93	1.12	0.77	2.06	1.00	0.70	2.27
	50	38.70	0.798	0.97	0.803	2.57	1.57	1	2.57	1.40	0.93	2.57	1.17	0.80	3.20
	60	46.44	0.904	1.32	1.113	3.34	1.89	1	3.34	1.68	1	3.34	1.40	0.93	3.60

TABLE 4. Calculation of pressure drop through a bubble cap by Rogers and Thiele's method.

Cap No.	Vv	Vs	W	hs* Water	hs* Glycerine	hs* Acetylene tetrachloride
1	10	0.0566	0.125	0.45	0.5	0.59
	20	0.0113	0.125	0.74	0.87	0.96
2	30	0.017	0.125	0.93	1.09	1.27
	40	0.0226	0.125	1.13	1.31	1.54
	50	0.0283	0.125	1.31	1.53	1.78
3	10	0.0126	0.1875	0.58	0.67	0.80
	20	0.0252	0.1875	0.92	1.06	1.25
	30	0.0379	0.1875	1.20	1.40	1.65
	40	0.0505	0.1875	1.46	1.69	2.00
	50	0.0641	0.1875	1.70	1.99	2.34

* expressed in inches of water

Comparison of Calculated Results By Different Methods[1]

It would be interesting to compare the order of magnitude of pressure drops across a bubble plate calculated by different methods. Three standard bubble caps whose dimensions are given in Table 2 are used for the calculation. Vapor velocity through the riser of 10, 20, 30, 40 and 50 ft per second were chosen. Caps were considered to rest on the plate and riser, reversal and annular areas being equal to secure the minimum pressure drop. The bubble cap is assumed to be charged with air as vapor; with water, glycerine and acetylene tetrachloride as three different liquids. The total pressure drop and its component pressure drops through three standard bubble caps calculated by Dauphine's method are listed in Table 3. The pressure drops through the bubble caps by Rogers and Thiele's method and by Kirkbride's method are presented in Table 4 and 5 respectively. The pressure drops through a single bubble cap calculated by three different methods are plotted versus vapor rate through riser for each standard size with each different liquid; i.e., water, glycerine, and acetylene tetrachloride in Figs, 2, 10.

TABLE 5. Calculation of pressure drop through a bubble cap by Kirkbride's method.

Vr	hc* Water	hc* Glycerine	hc* Acetylene tetrachloride
10	0.13	0.13	0.13
20	0.516	0.516	0.516
30	1.16	1.16	1.16
40	2.06	2.06	2.06
50	3.23	3.23	3.23

* expressed in inches of water

It is interesting to note that Dauphine's method predicted different values of pressure drop for the cap of different standard sizes and the different liquids.[1] Rogers and Thiele's method gave the same value of pressure drop for the standard cap of size No. 1 and 2; Kirkbride's method predicted the value of pressure drop independent of the dimensions of the standard bubble caps and the nature of the liquids used.

All methods seem to give similar values of pressure drop in a normal range of vapor rate through the riser; i.e., between 10 and 30 ft per second.[1] The pressure drop calculated by Kirkbride rises rapidly with the vapor rate through the riser beyond 30 feet per second of the latter. The pressure drops calculated by Rogers and Thiele are also of the correct magnitude, but the discounting pressure drops through the riser and reversal and annular areas might lead to serious errors in

the calculations on caps which are of odd or non-unique design.

The use of a conversion chart, Fig. 2, to obtain pressure drop of a submerged cap from that of a dry cap is a convenient procedure. As there are certain over-scattering of data represented by two curves of different slot heights in Fig. 2 and that two curves are fairly close, it might be possible to use a single best curve through the most experimental data for all practical range of the slot height.

Although empirical, Dauphine's method results from the correlation of extensive data from numerous experiments. The breakdown of total pressure drop of a dry bubble cap into three components; i.e., uptake, reversal and slot pressure drop is probably a more sound approach to the problem to date. It is therefore recommended that Dauphine's method be used in evaluating pressure drop through a bubble plate column.

Nomenclature

A = Altitude of triangular slot, inches
A_c = Cap area, defined as the inside effective cross-sectional area of the cap
A_m = Minimum area for flow under the cap, defined as the smaller of the two areas, reversal and annular area
A_r = Reversal area, defined as the inside surface area of a cylinder formed by the extension of the riser between the top of the riser and the bottom surface of the cap top
A_u = Riser area, defined as the inside cross-sectional area of the riser
B = Width of slot at base, inch, in triangular slot
C = Orifice constant 0.51
D_c = Cap diameter, inside dimension, feet
D_u = Riser diameter, inside dimension, feet
h_a = Height of any point in the slot, feet
h_i = pressure drop due to foam and mist, mm hg.
h_l = liquid height above the weir, inch
h_g = liquid gradient across plate, inch
h_r = Reversal pressure drop in inches of water
h_{rc} = Pressure drop through riser, reversal and annular areas, inches of water
h_c = Total pressure drop through a cap with liquid head at the top of the slots, in inches of water
h_s = Slot pressure drop, in inches of water
h_u = Uptake pressure drop, in inches of water
K_v = Constant characteristic of the cap design
U = Linear velocity through a point in the slot, feet per second
V_a = Vapor velocity in the annular space, feet per second
V_r = Vapor velocity in the riser, feet per second
V_s = Vapor velocity through the slots, feet per second
V_u = Vapor velocity in the uptake, feet per second
W = Width of the rectangular slot opening, inch
ρ_L = Liquid density, lb/cu ft
ρ_V = Vapor density, lb/cu ft

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PART 2—CONCLUSION

V-Port Plug Tests

The net stem force on a 4-in. single seated percentage V-port plug for 100 psi pressure drop is shown in Fig. 15. Sketch "A" identifies the valve construction with the flow entering under the seat tending to open the valve. The net change in force for the V-port plug is 260 lb compared with 1010 lb for the parabolic plug. With the flow over the seat, Sketch "B", the net change, especially above 1 in. lift, is greater than when the flow was introduced under the seat.

To predict the behaviour of a double seated V-port valve the graph shown in Fig. 16 was developed from the test data of Fig. 15. Up to 1 in. lift this force closely duplicates the measured force on a double seated V-port valve. Above 1 in. lift the developed curve reverses from a force to close to a force to open. This force reversal did not occur on the double seated test as shown in Fig. 17. The net stem force for the double seated V-port is a relatively small percentage of the force existing in the parabolic plug.

Quick-Opening Plug Tests

Fig. 18 gives the force curve for the single seated quick opening plug. For both flows over and under the seat, the stem force drops off at a fairly constant rate up to 1¼ in. lift. It should be borne in mind that this lift is much more than the theoretical required to expose full seat area. Considered in combination as a double seated valve there would be relatively little unbalanced force. The higher force tending to close would tend to cancel out the opening force caused by the differences in seat area for the closed condition. Note in the region of .1 in. lift that the two forces are not equal as they were in the case of the parabolic and V-port tests. The force tending to close increases rapidly above the theoretical and then drops off. In practice, this little hump is evidence of a very definite tendency to suck the plug into the seat when

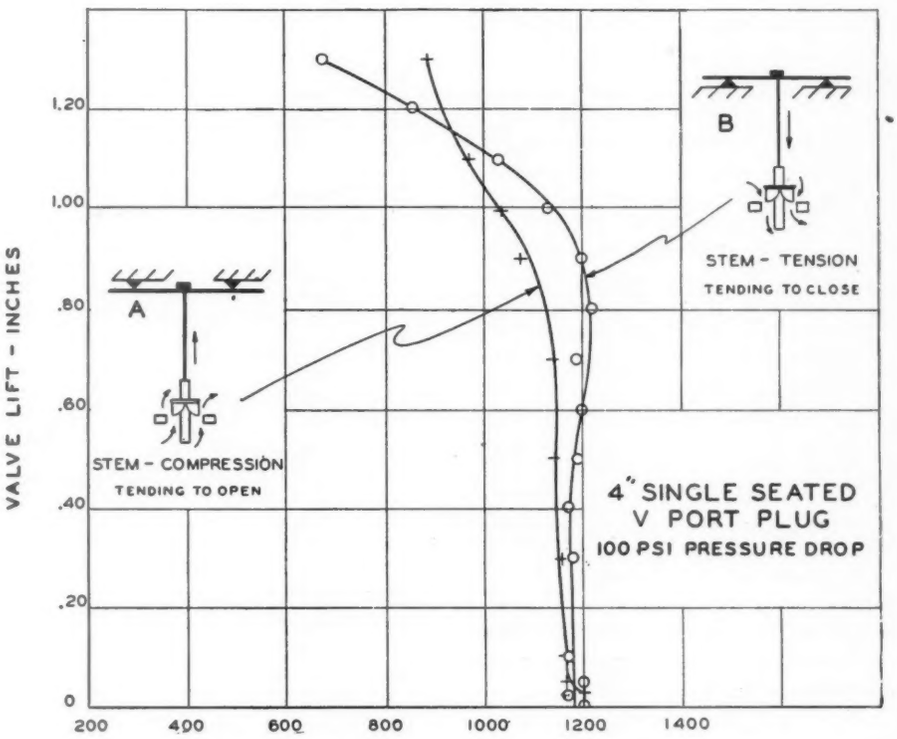

FIG. 15. Single seated V-port—Lift vs. force.

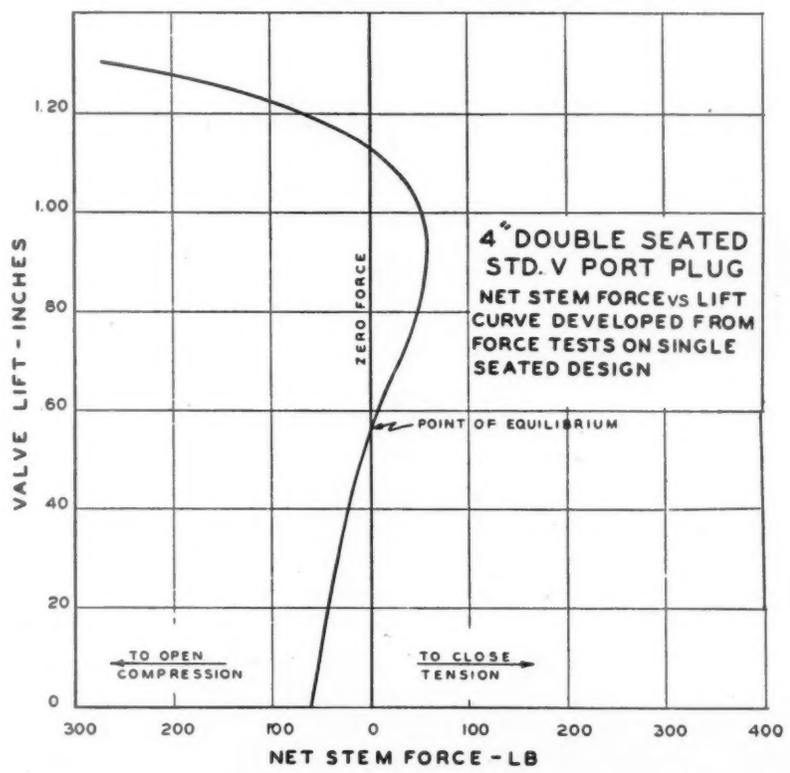

FIG. 16. Double seated V-port—Lift vs. net force (S.S. data).

*Delivered at the symposium on Instrumentation for the Process Industries at the Fifth Annual Session, October 13, 1950, Texas A&M College, College Station, Texas.

†Director of Engineering, Mason-Neilan Regulator Company, Boston, Massachusetts.

the valve is operating at low lift.

Fig. 19 is the lift-force curve of a 4 in. double seated quick opening plug. At 6 per cent lift the net stem force curve reverses abruptly. This characteristic is similar to that observed in the two curves of the single seated plug in Fig. 18. This substantiates the instability that is frequently observed when quick-opening plugs operate close to the seat. Fortunately, the magnitude of the force is small and generally not troublesome. The net change in stem force is only 65 lb.

Special Overlapping Quick-Opening Plug Tests

Fig. 20 is the lift-force graph for a special overlapping quick-opening plug. This plug was designed to study bad construction. The hump in the curve tending to close the valve mentioned in the discussion of the quick-opening plug is now very pronounced. Above .10 in. this force drops off very rapidly and above .3 in. lift the character of the force curves on the three quick-opening types is generally quite similar. In service, either as a double seated valve, or as a single seated valve with the flow over the seat, this valve would be extremely unstable. Both the magnitude of the force and the slope of the force curves contributes to this instability. This plug was not tested for stability because of the likelihood of severe damage to the test equipment.

Cup-Shaped Plug Tests

The force test for a single seated cup-shaped plug is shown on Fig. 21. This design has been used in turbine governor valves. The flow restriction is a sharp edge and there is no tendency to develop suction near the seat. The graph shows quite clearly that the force drops off rapidly with increased lift. The drop-off is almost identical to that of a single seated quick-opening plug. Note that there is no tendency for a hump in the force curve with the flow over the seat as existed in the quick-opening plug design. This should give greater stability near the seat that may easily be a critical point in turbine governor valve design.

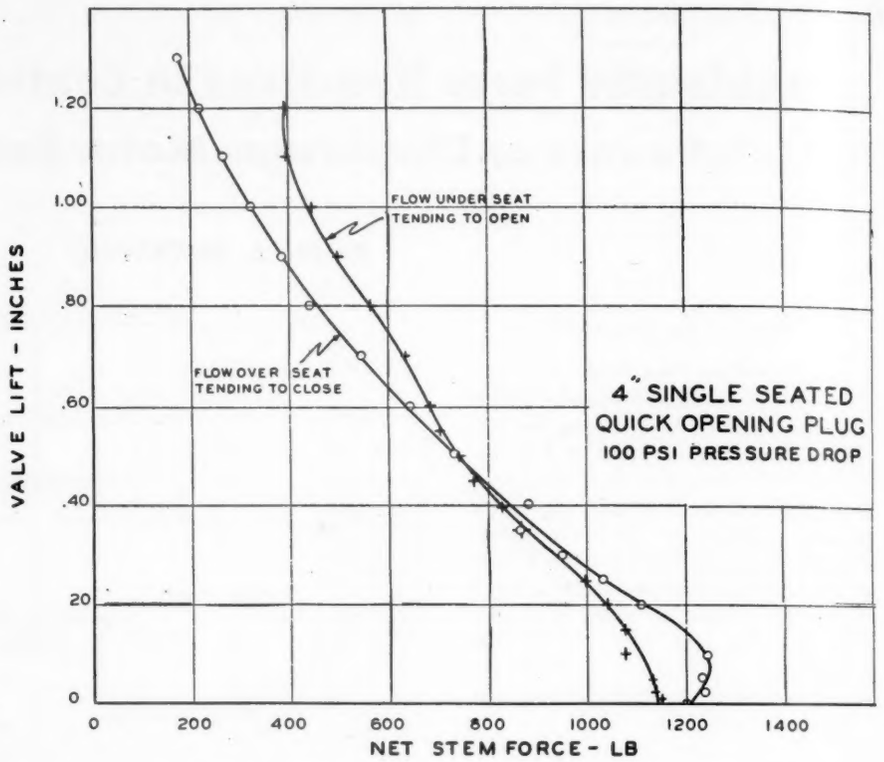

FIG. 18. Single seated quick-opening—Lift vs. force.

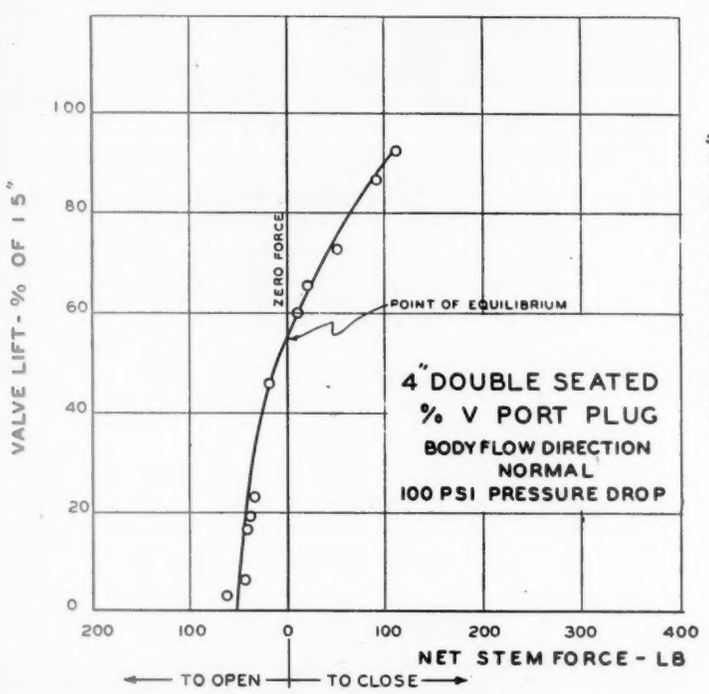

FIG. 17. Double seated V-port—Lift vs. force (Test data).

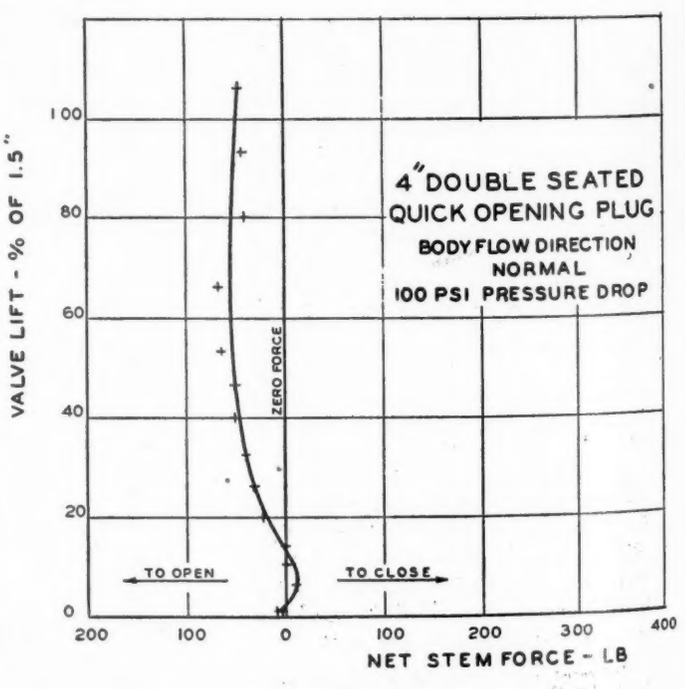

FIG. 19. Double seated quick-opening—Lift vs. force (Test data).

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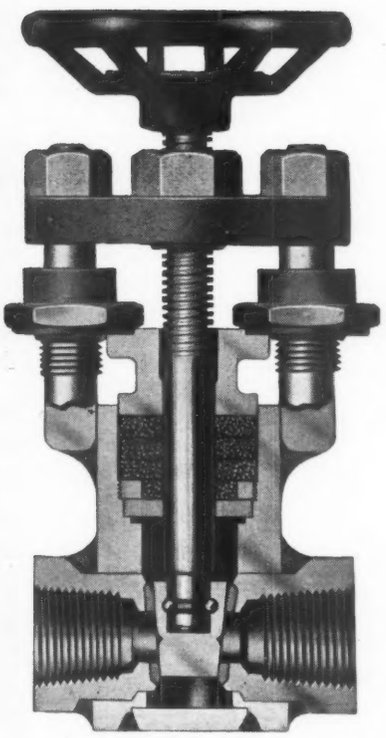
Steel Gate Weldvalves



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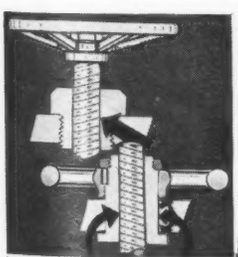
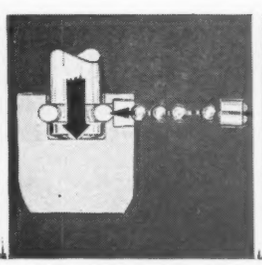
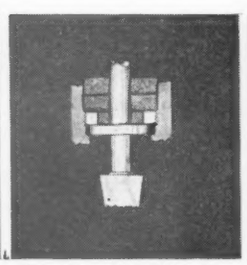


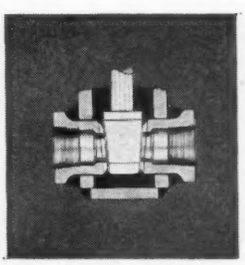
They're Easy to Operate—simple, durable Hancock yoke structure—top illustration—reduces friction to less than ½ that of conventional gate-type valves, bottom illustration.



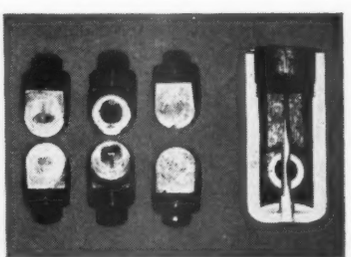
Ball bearing stem-to-wedge connection is safe, sure, long-lasting . . . means even distribution of load, less friction. All components of these stem-to-wedge connections are hardened and ground stainless steel.



They Can Be Safely Repacked Under Pressure—all alloy parts are 11½ to 13½% chromium stainless steel, hardened and ground, assuring positive cut-off. Back seating is also stainless-to-stainless.



They Have Permanent, Dependable Tightness—heavy force is applied to both end components when the valve is being made. The stellite seats are thereby pressed firmly against both sides of the wedge.



They're More Economical, Last Longer—the wedges shown operated a total of 41,872 times, against the downstream side in the valve body, opened to atmosphere and closed at 600# steam, superheated to 850°F. *No galling occurred!*

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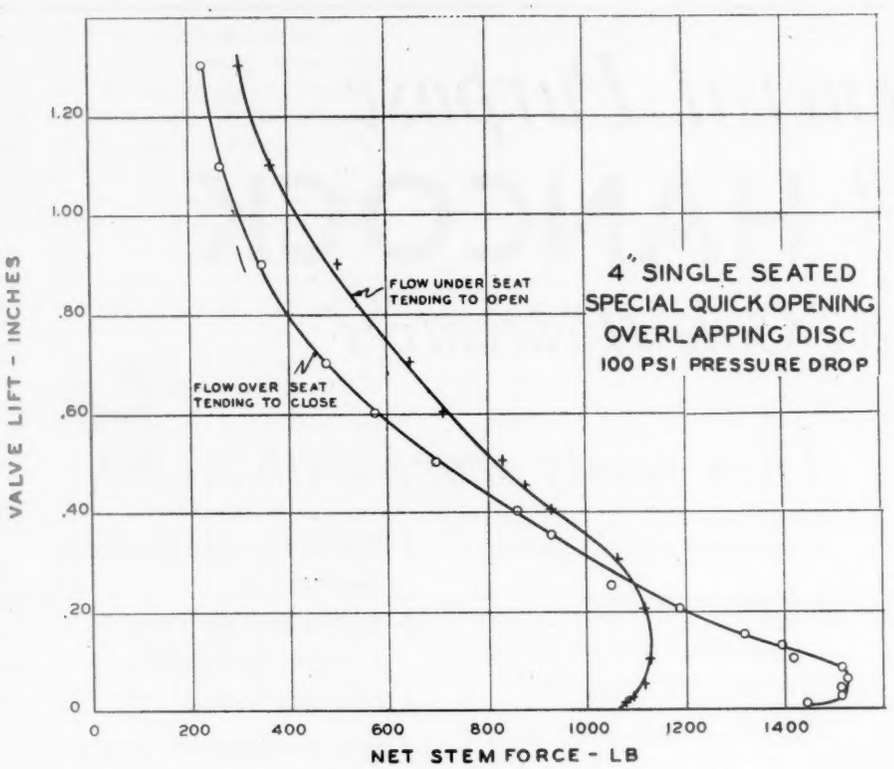


FIG. 20. Single seated special quick-opening—Lift vs. force.

Spring Loaded Diaphragm Motor Valves

Single Seated

The travel characteristics of spring-diaphragm motors are described in terms of air pressure range for rated stroke under no load conditions. The proposed ASA standard air range for spring diaphragm motors is 3 to 15 psi. When operating a single seated control valve the air pressure vs. travel characteristic of the motor is altered by the plug force reactions. This alteration is a direct function of the net stem force and the effective area of the diaphragm.

In Fig. 22 this effect is shown for a typical system based on the force data obtained in these tests. For convenience the seat ring area is assumed to be 10 sq in., and the diaphragm motor effective area 100 sq in. A plot of the diaphragm motor characteristic is shown as a straight line from 3 to 15 psi for 100 per cent lift.

Flow Over the Seat Tending to Close

In Sketch "A" with the flow over the seat the force reaction on the valve plug acts to compress the diaphragm motor spring lowering the diaphragm air pressure for any given plug position. With a differential pressure of 90 psi and the plug just off the seat, the net stem force tending to close the valve and compressing the spring is 900 lb. This is equivalent to 9 psi on the diaphragm and the valve starts to open at 15 minus 9, or 6 psi. From test data of known forces occurring at various lifts the complete curve can now be developed.

Note that the actual spring range of the motor is now minus 1.5 psi to 6 psi for a spread of only 7½ psi against 12 psi for no-load. The 4½ psi loss is due to the change in force on the plug as it moves through the stroke. Actually, this theoretical curve can never be realized in practice, as the valve will not open beyond 55 per cent lift. At this position the spring force is 825 lb opposed by the plug stem tension of 825 lb and the force system is in equilibrium.

The point to be emphasized is the fact that with the flow over the seat (tending to close) it is axiomatic that the air pressure range is reduced. This reduction in actual air pressure range with the flow over the seat is the dangerous one. In many actual cases this reduction, if severe, can actually cause a reversal, which will give the equivalent of snap action to the valve plug. If the rate of force change on the plug as it moves through the stroke is greater than the spring coefficient this instability is bound to occur. The 4 in. single seated parabolic plug showed a maximum rate of change of force of 1100 lb per inch at 100 psi pressure drop. The spring rate for 1¼ in. stroke, 100 sq in. motor, 3-15 psi is only 1000 lb per in., whereas for stability it should materially exceed 1100 lb per in. Naturally, certain plug types are more favorable in this regard than others, but too little quantitative data is available for any general rule.

Another effect more difficult to

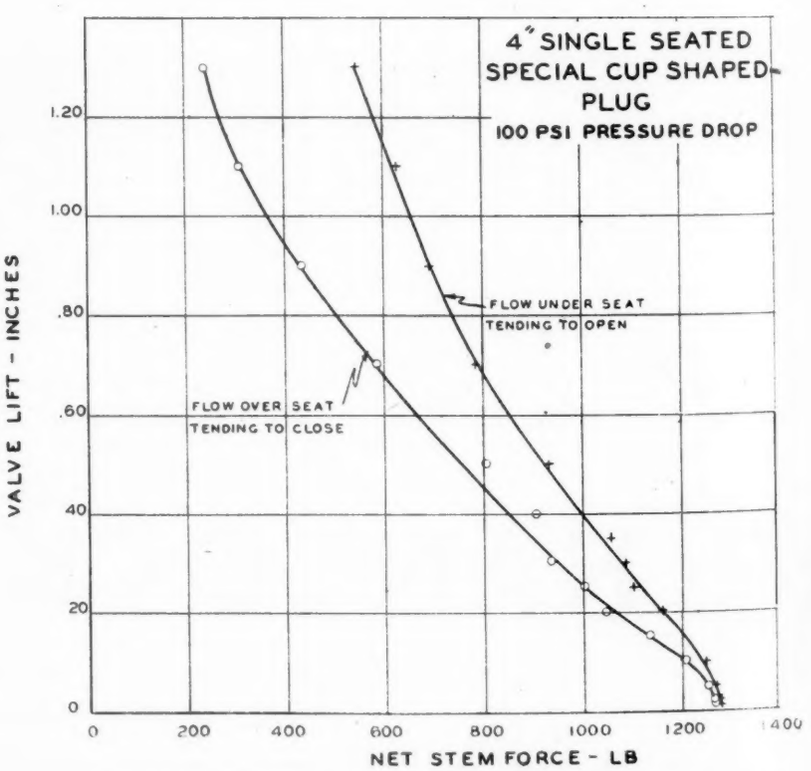
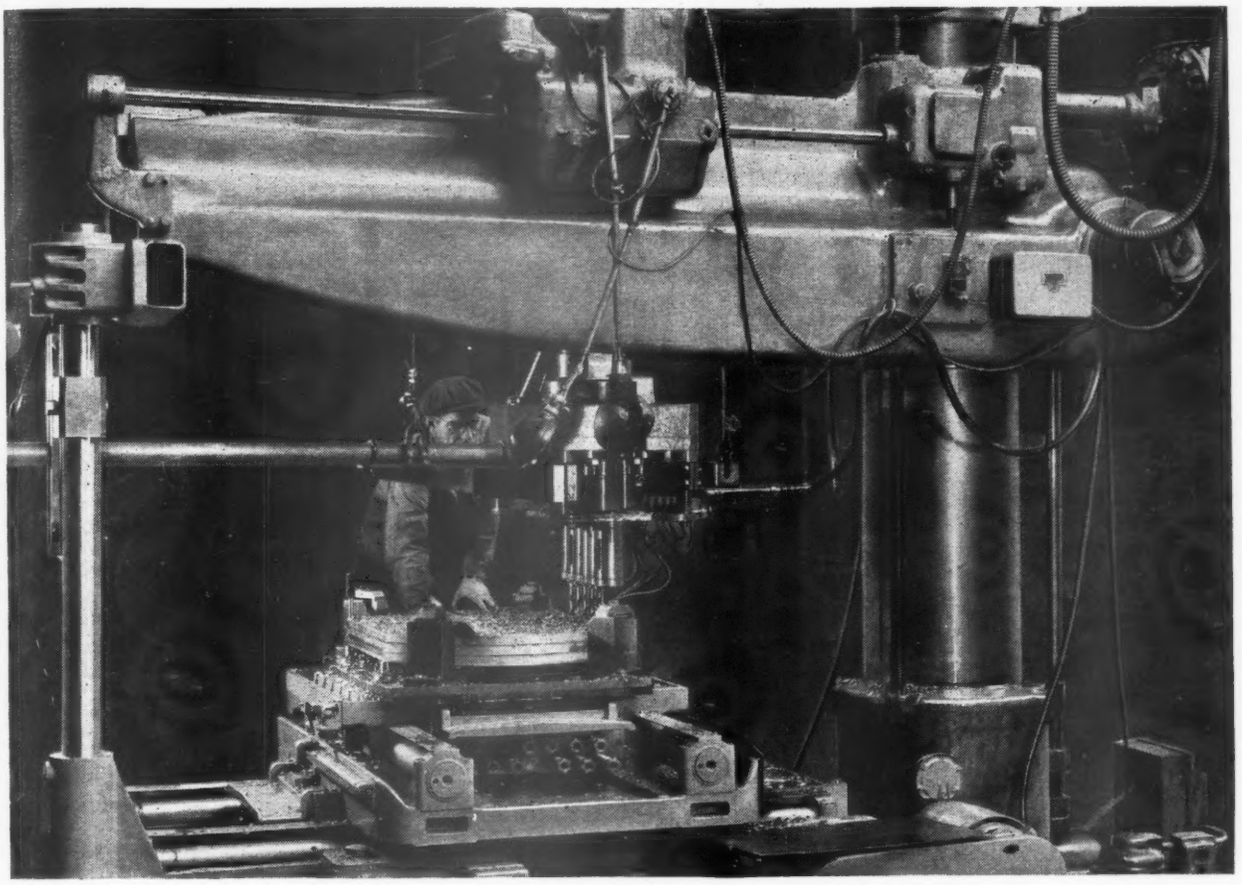


FIG. 21. Single seated special cup-shaped—Lift vs. force.



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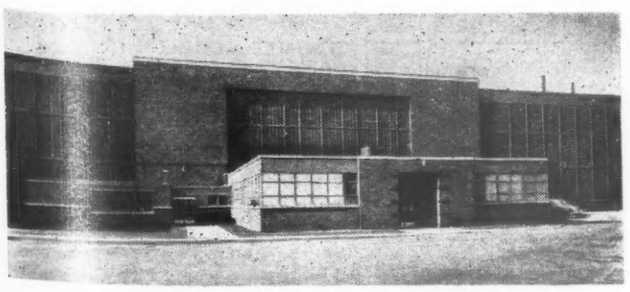

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measure and analyze, but very real is the dynamic force induced by the accumulative or "lock-up action" of such valve installations. As the plug approaches the seat the net stem force increases tending to pull the plug into the seat to further increase the stem force. On many installations this action may be coupled with an almost instantaneous transfer of line loss and body loss to the plug and seat ring, and the result is a water hammer effect of tremendous force. When the plug hits the seat, pressure surges in the line will release the force almost instantaneously and the cycle will repeat causing a violent chatter.

Flow Under the Seat Tending to Open

With the flow under the seat in Sketch "B", the stem force is in the same direction as the spring force raising the required diaphragm air pressure for any plug position. The resultant curve runs from 24 psi in the closed position to about 4.5 psi in the open position. This gives an actual air pressure range of 19.5 psi compared with 12 psi for the no-load condition. The equivalent air pressure due to force change in this case is 7.5 psi. This is true whether the plug is right side up, as has been shown in these sketches, or reversed in position.

With the flow under the seat the change in force on the valve plug through the stroke acts to increase the air pressure range. This gives the system an inherent stability. Any motion of the valve plug produces a force change which tends to oppose further motion. This is the "self-regulating" tendency found in many control processes.

As a practical example, the 4-in. single seated parabolic plug in the test was run with the flow under the seat through full stroke using a 100 sq in. diaphragm motor with the actuating air pressure to the top of the diaphragm pushing the plug shut. The water supply pressure was maintained at 160 psi with zero psi downstream. The motor was a springless type with no loading pressure to the underside of the diaphragm. Under these operating conditions, the off balance force on the plug when operating near the seat was approximately 1800 lb or 18 psi on the diaphragm. This is a very substantial load, yet the valve could be operated erratically and rapidly through full stroke without the slightest tendency to instability. This same plug with the flow in the opposite direction at only 100 psi drop slammed violently enough to endanger the whole piping system.

Double Seated Valves

Both the analysis based on single seated valve tests and the actual results on the double seated valves show conclusively that substantial vertical forces are developed only with the parabolic solid turned type of plug. These forces can be substantial and severely limit the application of this plug shape in the larger sized diaphragm motor valves operating under high pressure drops. The quick-opening disc and various skirted plug designs give very little net vertical force. The skirted type plug does develop a rotational force which fortunately can be greatly reduced by proper design.

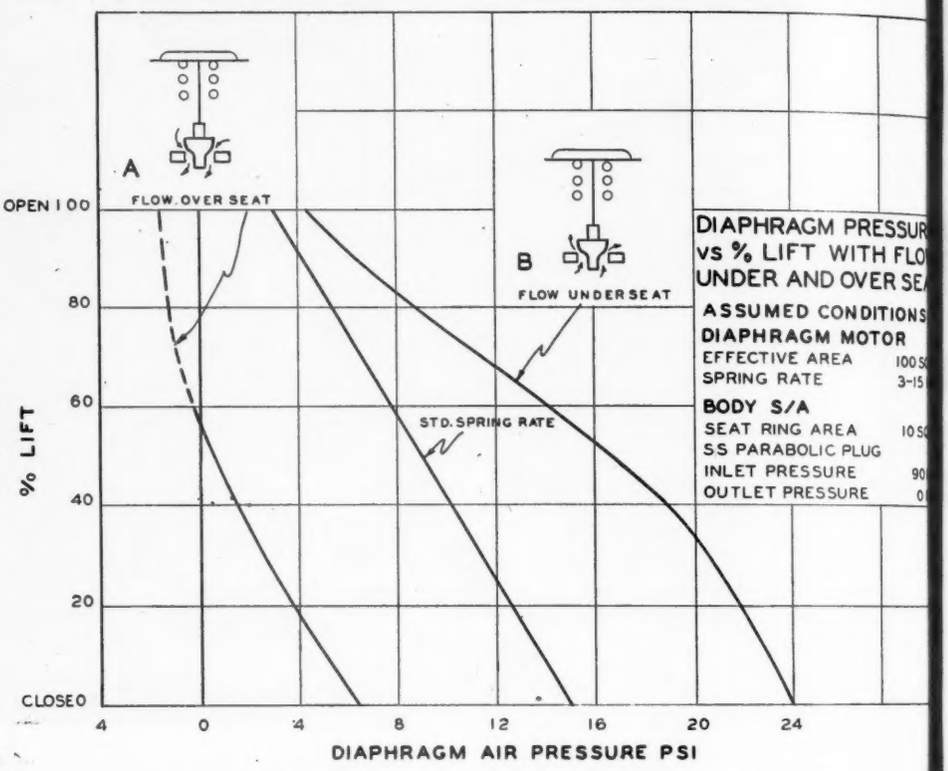

FIG. 22. Spring diaphragm motor—Pressure vs. lift.

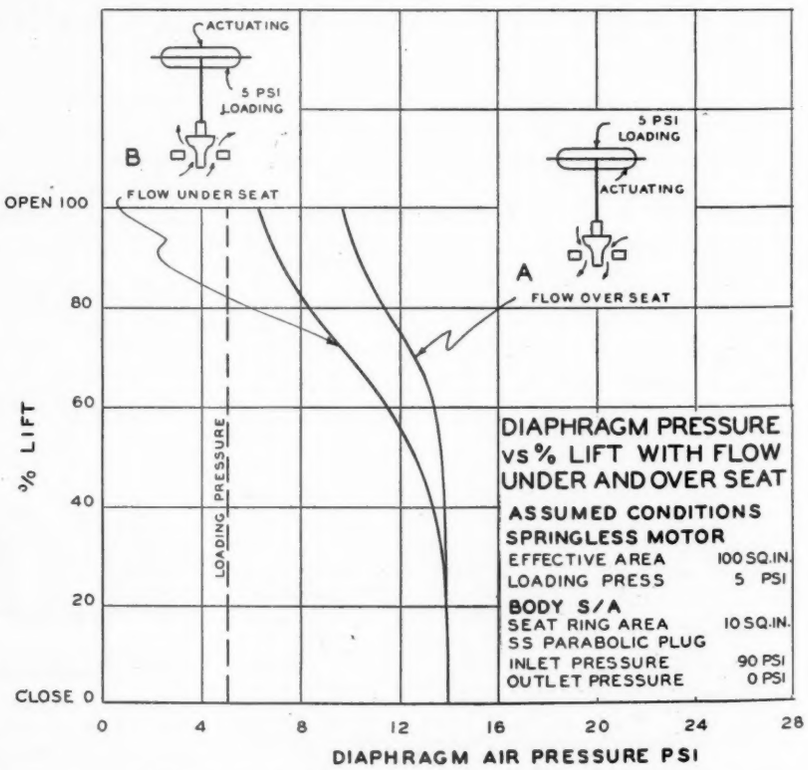

FIG. 23. Springless diaphragm motor—Pressure vs. lift.

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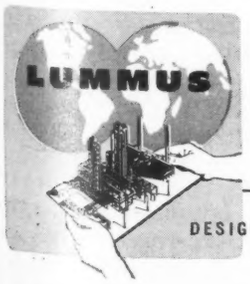

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Springless Diaphragm Motor Valves

Single Seated

Fig. 23 shows the air pressure vs. stroke characteristic of the 4-in. single seated parabolic plug operated by a conventional springless motor. In the springless motor the variable spring loading is replaced by a constant air loading; in this case arbitrarily set at 5 psi. Under no-load conditions the actuating air pressure vs. stroke would be a constant line at 5 psi on the assumption that there is no weight of parts or change in effective area.

Flow Over the Seat Tending to Close

In Sketch "A" with the flow over the seat tending to close the actuating pressure is brought in to the under diaphragm to push the plug open. Both the 5 psi loading pressure and the off-balance on the plug equivalent to 9 psi oppose the actuating pressure and the initial is 14 psi. The resultant diaphragm pressure lift curve developed from the force data varies from 14 psi at zero lift to 9 psi at rated lift.

One important limitation of the pneumatically loaded system with this body flow path is its inherent instability. This tendency towards instability due to the "lock-up action" is very pronounced. The pressure build-up and consequent plug motion are so rapid that no compensating action by the motor positioning mechanism is possible. It is significant that the four single seated plug types vibrated severely when tested in this manner. The motor used on these tests was a 100 sq in. unit equipped with a positioner with and without a relay. In this respect the springless motor is probably less satisfactory than the spring loaded type.

Flow Under the Seat Tending to Open

With the flow as shown in Sketch "B" the actuating pressure is introduced on top of the diaphragm to push the valve closed against flow. The effect of the force acting on the plug, therefore, is to increase the required actuating pressure so that the initial again becomes 14 psi (5 psi plus 9 psi for the 900-lb force). The shape of the characteristic curve is determined by the force curve on the plug itself. The resultant diaphragm pressure curve varies from 14 psi at zero lift to 6½ psi at rated lift.

Although this change in pressure is greater than with the flow over the seat the valve is inherently stable possessing self-regulation as discussed under spring diaphragm motors.

By using various combinations of loading pressures and direction of actuation these characteristic curves can be shifted or reversed in shape but not altered in character. As a typical example under Sketch "A", the actuating air pressure could have been brought in on top of the diaphragm to force the valve in the closing direction. The 900-lb force on the plug when operating near the seat now acts in the same direction as the actuating pressure and the loading pressure of 5 psi would have to be increased by 18 psi to 23 psi in order to produce the 14 psi initial pressure. The actuating pressure would tend to increase as the plug force dropped off rather than decrease. The net change would be the same.

In actual practice, under such operating conditions the loading pressure would be set at some lesser value to bring the actuating pressure into a good operating range. By thus shifting the direction of application of the actuating pressure and (or) the magnitude of the loading pressure, the springless motor can be made to exert a much larger useful thrust than the spring type motor of equivalent effective area.

To simplify the problem of selection of the correct loading pressure and direction of actuation, springless motors are sometimes equipped with a reversing relay that automatically applies a variable loading pressure to the opposite side of the diaphragm in inverse proportion to the actuating pressure. The actuating and loading pressures are equal at one adjustable point only, usually at the mid-range. The off-balance force on the plug is then counterbalanced by both the loading and the actuating pressures in equal proportions. The relay also tends to increase the rate of response of the motor, but it does not increase the potential power of the motor or its stability.

Unfortunately, it is not always possible to choose the direction of flow through the body independently. In angle valve design for high pressure drop service the flow is brought in over the seat. By reversing the flow a substantial part of the erosive resistance and free flow character of the valve is lost. With the flow in over the seat with spring or springless motors the application of the valve is severely limited by this tendency to instability.

Double Seated Valves

As the double seated valves do not require large operating forces there is less reason to consider the use of springless motors. Generally speaking, almost any industrial application can be handled by a valve operated by the simpler spring motor.

The reversal of direction of stem force which can occur as the valve is opened reverses the differential pressure in the springless motor. In the simple motor illustrated in the diagrams the unsupported portion of the diaphragm must reverse position giving the effect of lost motion and possible instability. This is overcome by using two diaphragms separated and vented in between—a material complication in design. In single seated valves where there is no reversal in the force direction the double diaphragm construction is unnecessary.

Acknowledgment

The author wishes to express his appreciation to Paul Wing, Jr., of the Mason-Neilan Engineering Department for his invaluable aid in supervision of the experimental work and assistance in the preparation of this paper.

* * *

Paint Changes Colors With Temperature

A new type of paint that changes color automatically at increasing degrees of temperature is aiding the Socony-Vacuum Oil Company, Inc., in studies of cooling processes for air-cooled internal combustion engines.

It is being used by the Technical Service Department, Socony-Vacuum laboratories, Greenpoint Avenue, Brooklyn, New York, where technicians said color bars created by different temperatures on a painted engine are fundamentally similar to the isobars of a weather map.

The paint is formulated to provide 15 basic shades for original application. It assists, according to the Socony-Vacuum technicians, in determining proper locations for thermocouples to measure internal heat while an engine is in operation.

Some of the 15 basic paints are capable of six complete alterations in color as temperatures rise. One such paint originally violet blue when cold, will become bright green at 311 F; olive green at 446; dark gray at 545; light gray at 554; light brown at 572, and buff at 644 F.

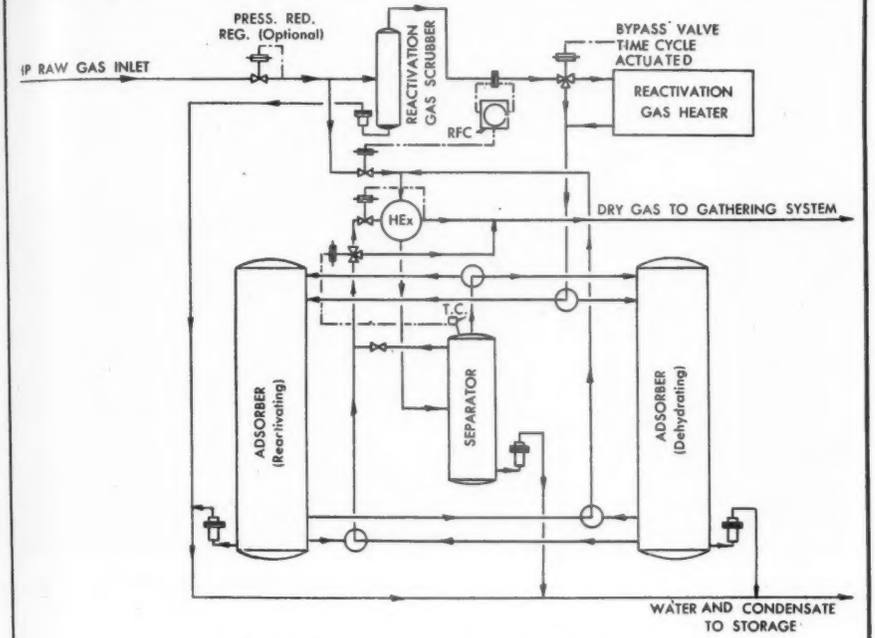

FIG. 1. Flow diagram of adsorption type gas dehydration unit for wellhead service.

New Adsorption Processes for Gas Dehydration

Details of operation of both big units for gas pipe lines and small ones for individual wells

LAWTON L. LAURENCE and LAURANCE S. REID

INCREASED demands for dehydrated gas, plus the use of higher gathering and transmission line pressures, have given a great deal of impetus to the development of improved gas dehydration processes.

The problem of dehydrating natural gas for pipe line sale is not new, but—since its inception in the late 1920's—process development has been progressive. As a result, there are available at this time two basic gas dehydration processes that are in widespread use. The first of these is a more-or-less typical absorption process in which the water laden gas is contacted by concentrated diethylene, or triethylene glycol water solutions to effect removal of the bulk of the water carried in the vapor phase by the natural gas. The diluted solution is heated and stripped of its excess water content, and the concentrated solution is cooled and pumped back to the absorber, forming a continuous process. The gas dehydrated by this means is not always dry enough to meet delivery specifications.

The second, and even more effective basic gas dehydration process employs a solid, granular adsorbent capable of reducing the residual moisture content of natural gas to less than one pound of water vapor per million cubic feet. The capital investment required is considerably greater for the adsorption process, although this differential is offset—in some instances—by the greater drying efficiency. To date, few applications have been found for the liquid absorption process at pressures exceeding 1500 psi. On the other hand, a number of adsorption processes have been operated at 2000 psi. According to the best available information, there is no known upper pressure limit for a number of granular desiccants, except insofar as excessive pressures may influence other factors such as temperature, moisture, and hydrocarbon content, et cetera. which—in turn—may or may not have an adverse effect on desiccant performance.

Small Units Designed

There have been few outstanding advances in the design of processes employing granular desiccants during the past 6 or 8 years, other than the design of relatively small units of 5 to 30,000,000 cu ft per day capacity, which are used in gathering and marketing high pressure gas. Design of the smaller units followed very closely the conventional designs used for years in large dehydration processes having daily capacities ranging upward from 50,000,000 cu ft per day. Difficulties due to scaled-down design have been numerous. Some of the principal ones encountered are: (1) Excessive pressure loss across the unit, (2) severe attrition or dusting of the desiccant, (3) inadequate reactivation heat, (4) rapid poisoning of desiccant due to gradual accumulation of heavy condensate, and (5) poor gas dehydration during the early phases of an operating cycle—due to excessive temperature in the freshly reactivated sorber.

With these difficulties in mind, the authors have conceived, designed, and

THE AUTHORS

Lawton L. Laurence, chief engineer for Black, Sivalls & Bryson, Inc., has devoted much time and effort toward perfecting natural gas dehydration processes. He attended Cameron Junior College at Lawton, Oklahoma, and was graduated from the University of Oklahoma with a BS degree in petroleum engineering in 1941, immediately becoming associated with BS&B. After spending 28 months in the Navy, Laurence worked for a time in the research department of The Carter Oil Company.

Laurance S. Reid, professor of chemical engineering at the University of Oklahoma and consultant to Black, Sivalls & Bryson, Inc., is a native of Iowa. Beginning his college work at Rice Institute, Reid received his BS degree in chemical engineering in 1931 from Iowa State College, and his master's degree from the University of Oklahoma in 1937. He has worked as refinery engineer with the Lion Oil Refining Company, as research engineer with Phillips Petroleum Company, as development engineer with BS&B, and as assistant chief engineer with Southern Natural Gas Company.

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tested two types of units* that have proved to be successful. One process, of relatively small capacity ranging from 3 to 5,000,000 cu ft of gas per day, was designed for service on individual gas wells where working pressures were 2000 psi and higher. A flow diagram of this process is shown in Fig. 1, and a photograph of a typical installation is shown in Fig. 2. With reference to Fig. 1, the high-pressure gas from the well is passed through a pressure reducing regulator where the system pressure is adjusted to the desired level, preferably in the vicinity of 2000 psi. Downstream from this valve a relatively small quantity of gas is taken from the main flow and, under control of an automatic flow-control device, is passed through the gas heater and into the reactivating sorber. Here the hot gas heats the sorber and its contents, and desorbs accumulated water and hydrocarbon from the desiccant, carrying them from the vessel. This hot gas rejoins the main gas flow at a point downstream from the flow control valve. A high degree of cooling is effected by mixing the two streams, and the combined flow then passes through a heat exchanger where controlled cooling is effected to a temperature only slightly in excess of the hydrate temperature. The gas then enters a scrubber where all free liquids, both water and hydrocarbons, are separated and withdrawn from the system. The separated gas then passes to a second sorber where it is thoroughly dehydrated, passing in adsorbing contact with activated desiccant. Dry gas passing from the sorber is expanded to delivery pressure by means of a pressure reducing regulator set immediately upstream from the heat exchanger mentioned above. This gas, cooled by expansion, passes through the heat exchanger, cooling the inlet gas stream. When necessary, a portion of the cold, dry gas is automatically by-passed around the heat exchanger in order to maintain the scrubber temperature slightly above the point at which hydrates form.

Another feature of this process is the ability to increase its capacity by by-passing a portion of the separated, but undehydrated, gas around the sorber, and mixing it with the dry gas prior to expansion to gathering system pressure. For example, where it is necessary only to prevent freezing in the gathering system by maintaining a plus 30 F dew point, as much as 30 per cent of the total through-put may be by-passed. Where flow rates are reasonably constant, manual control of the by-pass valve is effective. Where flow rates vary, a dew point controller is recommended.

*Patents Pending.

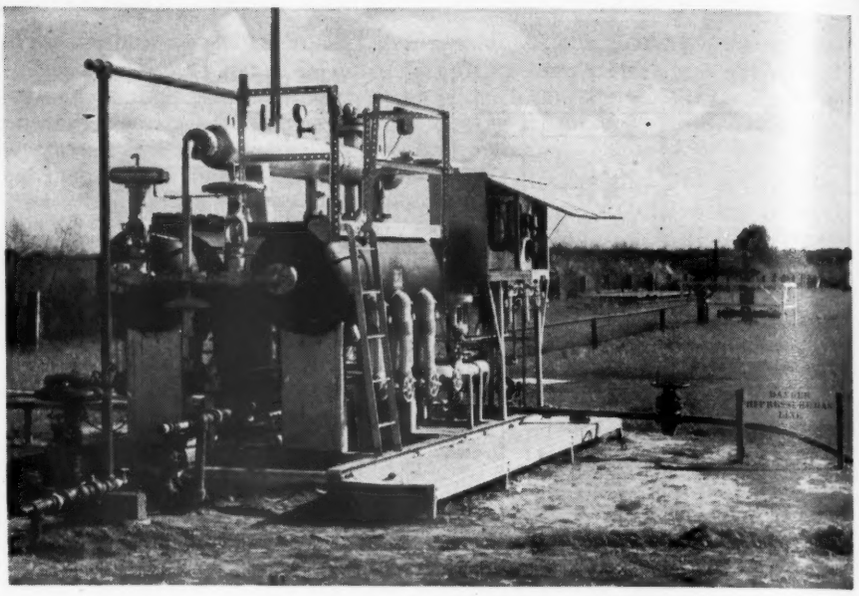
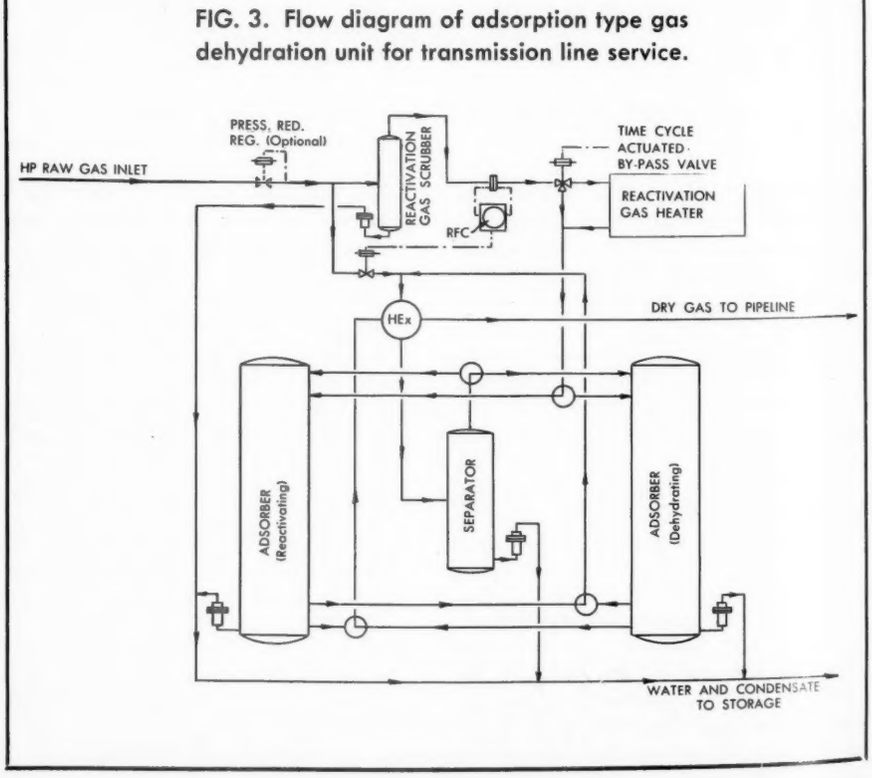


FIG. 2. Adsorption unit for wellhead service installed for Bates and Cornell near Lafayette, Louisiana.

Transmission Line Units

The second process has been developed for transmission line service, where pressure loss must be held to a minimum. A flow diagram of this process is shown in Fig. 3, and a typical commercial installation is shown in Fig. 4. Referring to the flow diagram, the gas enters the unit, usually saturated at line pressure and ground temperature. A portion of the gas is separated from the main flow and passes through a scrubber, thence through the reactivation cycle in the manner described above for the wellhead unit, except that the hot gas leaving the reactivating tower is passed in heat exchange with the cold, dehydrated gas leaving the unit. The recombined stream then passes to an inlet scrubber where all free liquids are removed and discharged from the system. The separated gas passes through

FIG. 3. Flow diagram of adsorption type gas dehydration unit for transmission line service.



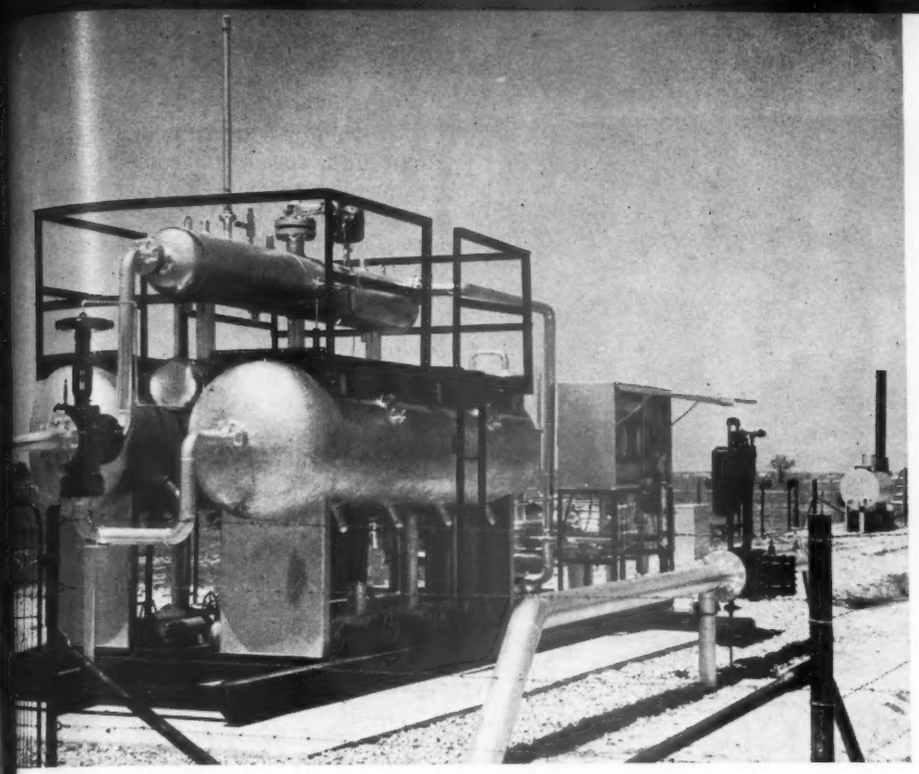


FIG. 4. Adsorption unit for transmission line service installed for Continental Oil Company near Mamou, Louisiana.

the sorber where it is thoroughly dried. On leaving the sorber, the dry gas passes in heat exchange with the hot reactivation gas before entering the pipe line.

In view of the difficulties inherent in many small gas dehydrators, as enumerated above, many component parts of these new processes were completely redesigned. A number of unique design features have resulted, each contributing to improved overall performance of the process.

Horizontal pressure vessels are used throughout, permitting compact mounting on skids, and complete fabrication of all process piping at the manufacturing plant prior to shipment.

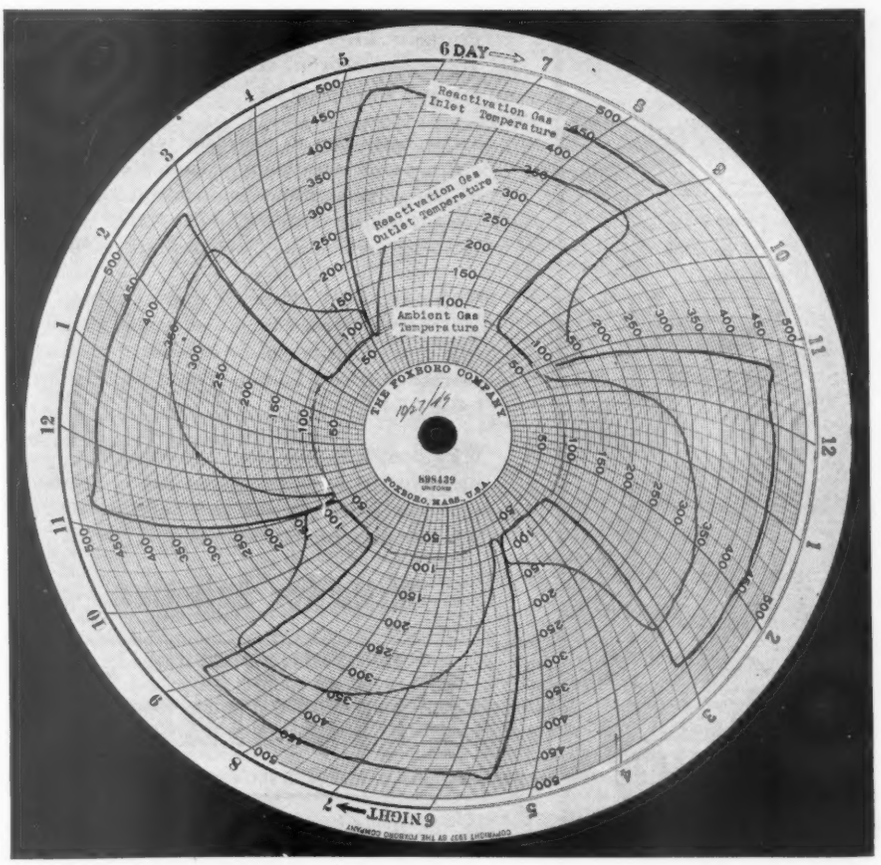
The horizontal sorber* design causes the gas to be passed in a transverse adsorbing contact with the desiccant, reducing pressure drop across the sorber to less than 5 psi; reduces gas velocities to an unusually low level that prevents attrition, provides long gas-sorbent contact time and permits rapid, effective application of heat for the purpose of reactivation. Effective means are provided for uniform distribution of the gas flow through the desiccant.

Heat Transfer

An abundance of heat, required for reactivation of the desiccant, is provided by passing a controlled volume of gas through a modified BS&B Series 70 heater, wherein the reactivation gas is heated to 500 to 600 F prior to introduction into the reactivating sorber. These high temperatures are obtained by indirect heat transfer through a molten bath of Du-Pont "Hi-Tec" salt; a mixture of sodium-potassium nitrates and sodium-nitrite forming an unusually stable and safe heat transfer medium, noncorrosive to mild steel at temperatures as high as 800 F. Although the minimum recommended reactivation temperature for activated alumina and activated bauxite is 350 F, higher temperatures, ranging upward in excess of 400 F, can be obtained with ease in these processes. Reactivation at higher temperatures provides greater sorption capacity, removes more adsorbed hydrocarbons, decreases rehydration and thus prolongs the useful life of the desiccant. A typical reactivation temperature chart is shown in Fig. 5.

Another unique feature of these processes is the cooling cycle that follows the heating during reactivation. The length of the heating cycle may be controlled either as a function of time, or of gas outlet temperature. In either case, when the heating cycle is complete, the reactivation gas is bypassed around the heater and the cool gas removes heat from the reactivated sorber, cooling it to atmospheric temperature prior to its return to dehydration service. This feature provides effective dehydration at the start of a new cycle where, otherwise, a hot

FIG. 5. Typical reactivation temperature chart for operation on a 6-hr cycle.



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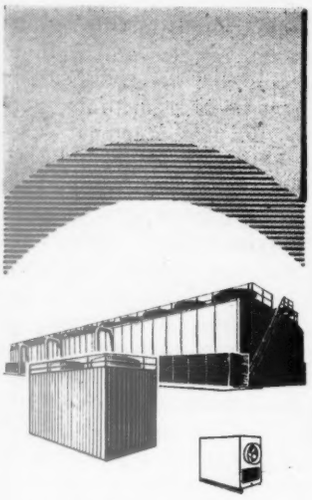

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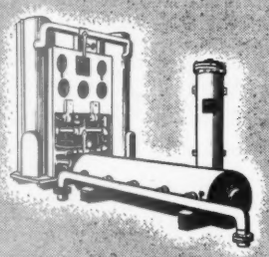
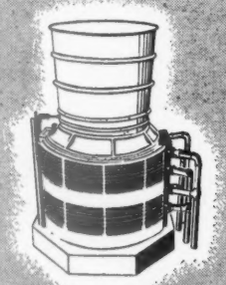


GAS EQUIPMENT



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sorber would adsorb little or no water vapor until sufficiently cooled by the gas passing through it. This feature also eliminates the hazard of structural failure in the outlet piping from the unit, occasioned by sudden expansion due to hot gas issuing from a freshly reactivated sorber. With an adequate heat supply and horizontal sorbers, such as provided in these processes, there is ample time available for reactivation and cooling even in cycle periods as short as four hours.

Automatic Controls

Both processes may be supplied with fully automatic controls. Three-way diaphragm motor valves, fitted with single plugs, and double seated bodies, have proved successful in this application. Despite the fact that these are spring-loaded valves, the pressure differential across them is so low that no leakage has been encountered. A unique feature of this automatic control system is sequence operation of the main valves. An intensive study of operational sequences has revealed that considerable desiccant attrition is caused by simultaneous operation of all valves, and that — in some instances, there may be an instantaneous flow reversal. As a result, the control system is designed so that the cycle timer actuates one valve only. When this valve has changed positions, it actuates a second valve and, when this valve has completed its stroke, it actuates the remaining valves simultaneously. The success of this sequence operation is indicated by the very small fluctuation in the differential recording on the gas meter situated at the unit. Generally speaking, this fluctuation will range from 1 to 2 in. of water.

The performance of the units now in service has been unusually good, despite the fact that their operation has included some anomalous flow conditions where the rated capacities have been substantially exceeded. They have been subjected to flooding with slugs of water, condensate and drilling mud, but have recovered and have continued to operate in an acceptable manner. In normal operation, when processing gas saturated with water vapor at 800 and 1800 psi and from 55 to 90 F, these processes produce gas with a water dew point consistently below —20 F, during cycles ranging from 4 to 24 hours.

Acknowledgment

The helpful assistance of the Southern Production Company, Inc., in perfecting the operation of these dehydrators is gratefully acknowledged.

* * *

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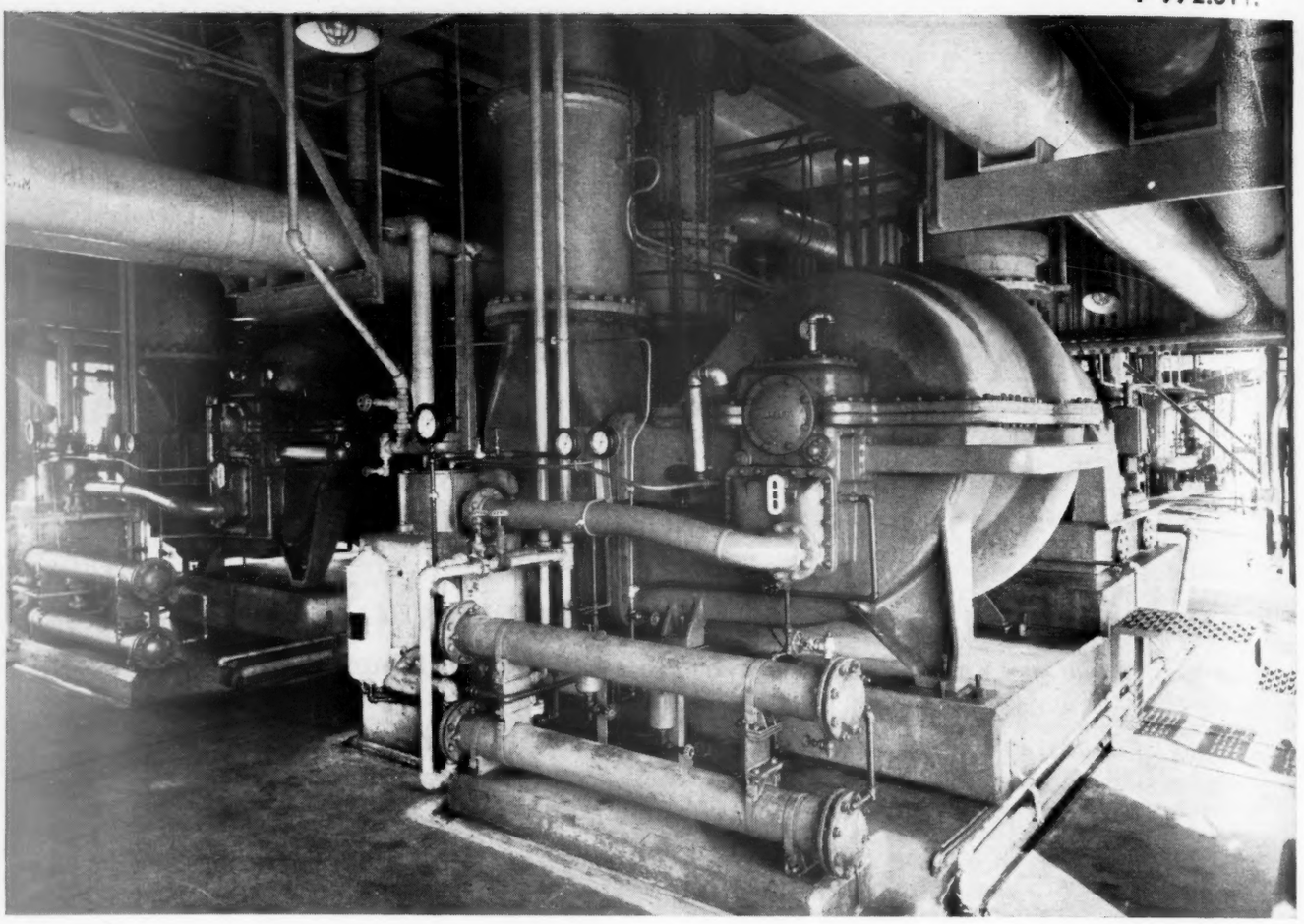

—Photo Courtesy of Carrier Corporation.

FIG. 1. Two centrifugal compressors used to supply air to a fluid catalyst cracking unit. Steady large volume flow of air is necessary to reduce the density of the catalyst and "fluff" it so that it flows as a fluid up the regenerator return line.

Centrifugal Compressors in Petroleum Engineering

Advantages, Uses, Characteristics, and Selection Must Be Studied for Proper Planning, Operation

In Two Parts—PART 1

PETROLEUM engineers have used as many centrifugal compressors for various operations in the refining industry as any group of engineers in comparable work. Introduced a little more than 25 years ago, centrifugal compressors now serve about 15 important natural gas, refinery, and gas transmission functions. Widespread adoption of centrifugals by petroleum engineers led to more extensive use in other industries. As a result the centrifugal compressors available today are efficient, compact, and economical units. To plan and operate modern refining equipment properly, the petroleum engineer must have a basic knowledge of centrifugal compressor advantages, uses, characteristics, and selection.

Advantages

The older reciprocating compressor is often used as a yardstick in measuring the advantages of the newer centrifugals. Although the centrifugal compressor does have many advantages over the reciprocating compressor, it should be remembered that both types have their specific fields of application. Within its own fields each rates well and a statement of the advantages of either type should not be inferred to mean that the other is obsolete. The reciprocating compressor is still well suited for many petroleum engineering jobs and experienced engineers take full advantage of its special characteristics whenever possible.

Compactness, light-weight, greater capacity, lower first cost, smaller installation cost, less required attendance, greater dependability, and nonpulsating delivery of air or gas are the major advantages of centrifugals. In addition, their good efficiency at high speeds permit drive by steam turbines, electric motors, gas turbines, and diesel or gas engines. Most of these advantages result from the absence of reciprocating and rubbing parts. Being inherently balanced, clearances are comparatively large and internal wear a minimum. Inter-

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nal valves are not used, a feature that reduces maintenance time. Automatic regulation of suction or discharge pressure or volume is simple. Pressure surges usually occur only at light loads and are seldom a drawback to good operation though there have been refinery installations where a resonance effect in the piping greatly intensified pressure pulsations at moderate and heavy loads. By throttling the gas inlet these pulsations can be stopped readily. The overall light-weight of centrifugals makes them well adapted to refinery service. Foundations need not be large, high capacity lifting cranes are unnecessary, and maintenance can be performed by smaller crews.

Drives

The many types of drives possible early led petroleum engineers to adopt the centrifugal compressor. Plant heat balances vary widely from one refinery to another and the ability to use steam, electricity, diesel oil, gasoline, or waste gas in the prime mover permits nice adjustments in energy streams. Where large quantities of process steam are required, petroleum engineers take full advantage of the steam turbine. After generation of steam at high pressure, it is expanded through a steam turbine driving a centrifugal compressor and exhausts to process. High pressure steam generation costs slightly more than low pressure generation. Hence, the turbine acts as a power producing pressure reducing valve and the cost of its operation is extremely low. As both turbines and centrifugal compressors are high speed machines, direct drive is not only feasible, it is also advantageous because power transmission losses are eliminated.

Likewise, electric motors are well suited for direct drive of centrifugal compressors. These motors tie in well with the many other electric drives that have become increasingly popular in refineries during the past 20 years or so. Some recent centrifugal compressor installations utilizing electric drives are completely automatic, being controlled by pushbutton from remote locations. Gas turbines possess about the same advantages as electric motors and steam turbines. Instead of using generated energy they use a gas that might otherwise be wasted, thereby improving refinery overall heat balance.

In general, petroleum engineers have not made extensive use of diesel and gas engine drives for centrifugal compressors. A speed increaser between engine and compressor is generally necessary, introducing a transmission loss of 1 to 2 per cent or more. Centrifugal compressors are basically adapted to large horsepower, continuous duty loads. From operating and maintenance standpoints, the steam turbine and electric motor are usually better suited for these types of loads than the gas or diesel engine.

Studies by petroleum engineers have shown that the advantages cited here for centrifugal compressors are valid for loads requiring 500 or more horsepower. Below 500 hp the reciprocating compressor is usually more economical. Therefore, when selecting a compressor suitable for a given job, is must be recognized that the seemingly all-round advantages of centrifugal compressors do not always hold. It is a knowledge of facts such as these that enables petroleum engineers to select the best compressor after making a complete study of the process being served.

Centrifugal Compressor Uses

Light end recovery, cat crackers, dewaxing, alkylation, and plant air are the principal refining operations that use centrifugals. In natural gas operations, centrifugals are used for lean oil cooling, absorber tower compression, repressuring, and recycling. Gas compression, dehydration, and liquid gas storage are some of the functions performed in transmission. Specific arrangements vary somewhat, according to the designers' concept of the best heat balance, power costs at the plant site, and the process served. A study of typical production cycles utilizing centrifugal compressors will aid in an understanding of their place in petroleum engineering. It will also show that every petroleum engineer must have a basic knowledge of centrifugals in order to take part in modern production.

Refining

Fig. 2a shows centrifugals used for light end recovery in conjunction with a low temperature tower. One compressor takes ethane vapor from the flash coolers and discharges it to the intermediate exchanger. The other handles propane vapor, discharging it to a condenser where it is liquefied. Vapor quantities that pass through both compressors are large. Handling these large volumes permits reduction of the hydrocarbon refrigerant temperature to a low value. Temperatures down to —150 F have been obtained when gas volumes were sufficiently large. In ordinary refrigeration practice, attainment of temperatures this low is difficult and requires use of bulky, expensive equipment. For most light end recovery, centrifugal compressors handling propane and ethane vapors are the best means of producing desired low temperatures. Refrigerant cost is moderate because the hydrocarbon vapors are by-products of the plant.

In catalytic cracking, Figs. 2b and 2c, centrifugal compressors handle either gas or air, according to the type of unit being served. Vapors from fractionating tower condensers are compressed and discharged to splitters and absorbers. Because vapor volumes are usually large, petroleum engineers have generally selected centrifugals for this service. Only a few large capacity centrifugals are needed to handle the vapors whereas many small capacity units would be necessary. Air for "fluffing" the catalyst in fluid cat crackers must flow uniformly through the regenerator return line. The pressure head in the reactor and the hydrostatic pressure in the spent catalyst stripper actually produce flow through the regenerator return line. Without a steady flow of air, however, the catalyst would not be in a suitable condition when it reached the regenerator.

A continuous influx of regenerated catalyst is necessary to create a zone of extreme turbulence and uniform temperature. In addition, the "fluffing" air regenerates the catalyst by burning off the deposited coke. Recovered catalyst from the electrical precipitator is returned to the regenerator by a portion of the air compressed in the centrifugal. High pressure steam generated in the flue gas cooler is ofter used to drive centrifugal compressors by being expanded through a direct connected steam turbine. To permit operation of the compressor during cat shutdown, a connection to the refinery steam main is necessary.

In the past, ammonia has been the principal refrigerant used in dewaxing heat exchangers. Petroleum engineers knew that the presence of compressor lubricating oil in the ammonia reduced heat transfer in the exchangers but were unable to prevent its accumulation. Introduction of centrifugal compressors using propane refrigerant reduced exchanger scale formation but increased the power requirements for refrigerating machine drive. After a study of the power problem petroleum engineers found that two stage flash cooling, Fig. 2d, would reduce power input. As a result most modern dewaxing plants using centrifugal compressors are laid out as shown in Fig. 2d. Power consumption of these units is now about equal to that of the older ammonia systems. Heat exchanger maintenance has been

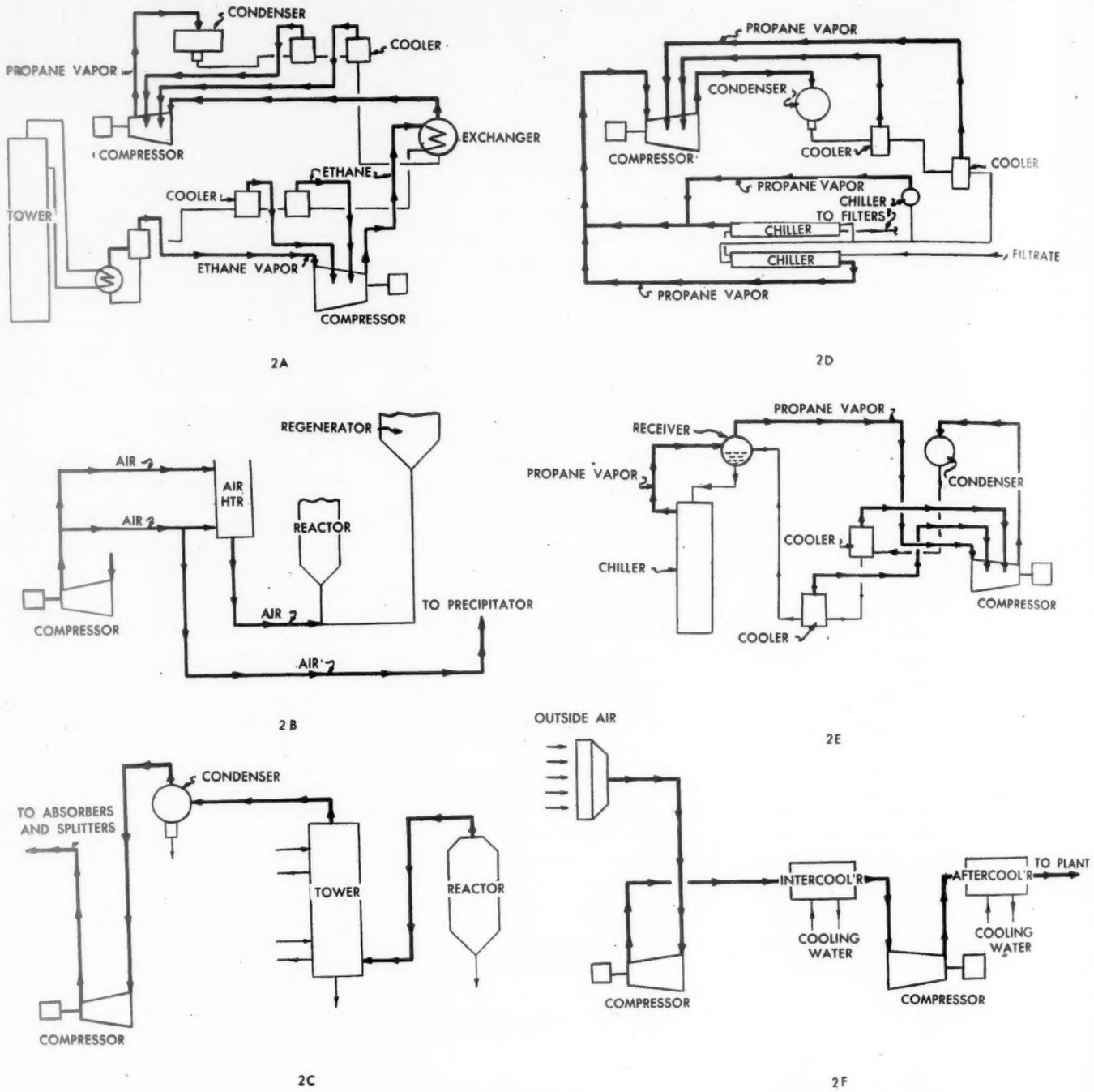


FIG. 2. Typical refining applications of centrifugal compressors. Details of each application are given in the text.

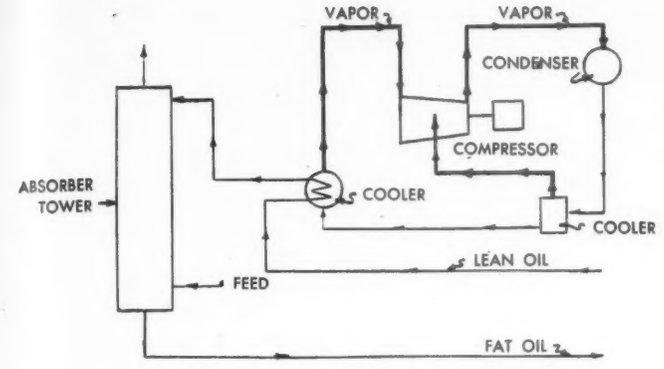
considerably reduced because the refrigerant is oil-free and enters the condenser at a lower temperature than ammonia.

Reduced power input to centrifugals serving alkylation units is obtained by inter-stage flash cooling of the propane refrigerant. Fig. 2e. A similar arrangement is used for the hydrofluoric process in which butane is the refrigerant. Centrifugals have been found well adapted to both processes because high cycle efficiencies result when uncooled compressors are used with bypassed flash gas in the higher stages. Gas volumes handled in both processes are large but the compressing equipment is compact and light-weight. As in dewaxing, lubricating oil accumulation on heat exchanger surfaces is eliminated.

Plant air for the operation of control devices, tools, cleaning hoses, and other equipment is now being supplied by centrifugal compressors in many refineries. Compressed air explosions are unknown with these machines because the temperature rise is never great enough to cause ignition of the lubricating oil. In addition, the air and lubricating oil never come in contact, reducing the possibility of contamination of sensitive pneumatic equipment served by the compressor. Two centrifugals are frequently used for plant air service, Fig. 2f. One discharges at moderate pressure to an inter-cooler and the other takes its suction from it, discharging through an after-cooler to the plant compressed air line.

Natural Gas

For years petroleum engineers hesitated before using refrigeration for



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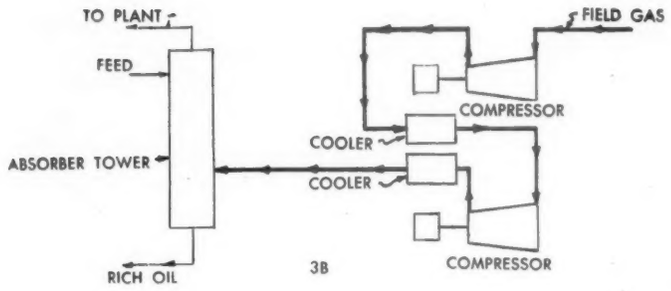

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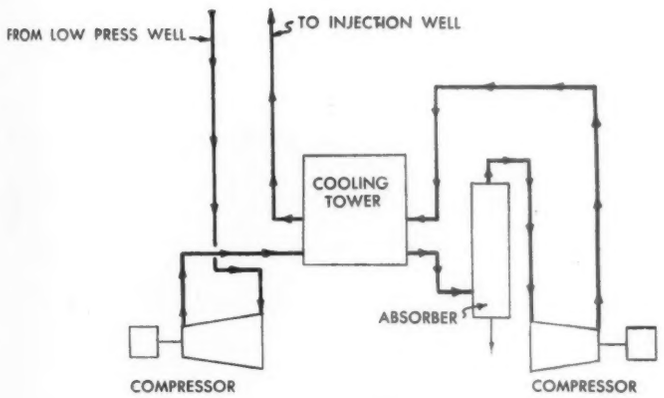
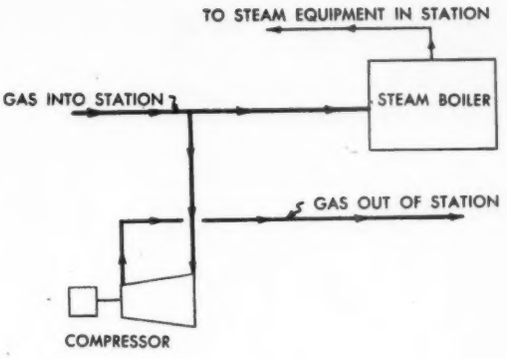
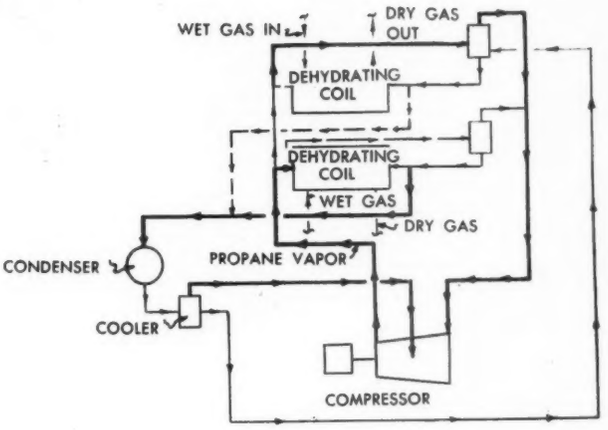


3C

FIG. 3. Typical natural gas applications of centrifugal compressors. Details of each application are given in the text.



4A



4B

FIG. 4. Typical gas transmission applications of centrifugal compressors.

lean oil cooling. As centrifugal compressor application increased, it was found that butane and propane recovery could be economically raised by use of a hydrocarbon refrigerant. Reduced absorber pressures, lean oil circulation, and stripping steam resulted, Fig. 3a. In some cases the steam savings were sufficiently large to permit driving the centrifugal "free" of charge; i.e., the steam diverted from stripping was used in a turbine to drive the compressor. The overall savings usually pay for the compressor in a short time. Space occupied by the compressor installation is small.

Use of two compressors to increase field gas pressure before it enters absorber towers has reduced compressor plant costs. As shown in Fig. 3b, the field gas passes through one compressor to an inter-cooler where its temperature is reduced. From here it goes to a second compressor, then an aftercooler and the absorber tower. Turbine drive for these centrifugals is best when the fuel gases are corrosive. By burning corrosive gases under a boiler, much maintenance is eliminated. Petroleum engineers have found this arrangement better than that which utilizes corrosive gases in internal combustion engine cylinders. Corrosion is less in boiler heating surfaces than in engine cylinders.

For handling well and injection gas, Fig. 3c, two centrifugals are commonly employed. Centrifugals are also applied to recycling operations where gas conditions permit use of hyrdrocarbon refrigerants such as butane or propane. Conventional practice in repressuring units is to burn sour gas under steam boilers and use the steam thus produced for the turbines driving the compressors. Such utilization solves two problems: (1) Disposal of sour gas, and (2) low cost steam generation. Of course, centrifugal compressor installation is often economically justifiable even though sour gas generation of steam is not feasible at the plant site. Maintenance costs for centrifugals handling large quantities of gas in repressuring units and recycling operations are usually lower than for reciprocating compressors of comparable size.

Transmission

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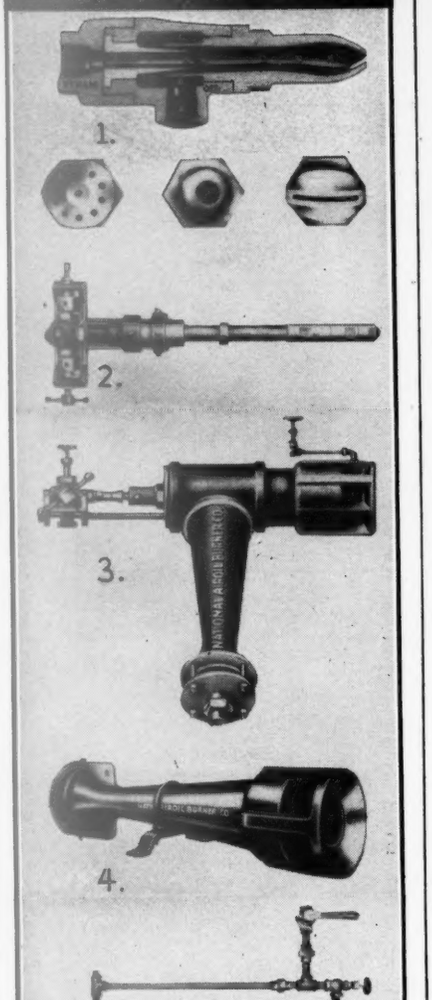

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tition from reciprocating compressors. This competition is not between manufacturers; many build both types and when called upon will recommend that which they consider best for the given application. The competition, instead, is based on past practice and conventional thinking connected with it. Large reciprocating compressors have, for years, been standard in the gas transmission field. Petroleum engineers have, however, been able to break with tradition in many instances where centrifugals were better suited for the transmission problem. To date the results obtained have been in keeping with design expectations.

Pipe line station prime movers in use are of all types, steam, internal combustion engines, and electric motors. In any given instance the type of prime mover selected depends on a number of factors which do not, generally, relate directly to the gas transmission problem itself. Station location, quality and dependability of water supply, and fuel available are a few of the major factors influencing prime mover selection. Regardless of which type is chosen, it can be used to drive a centrifugal compressor. Fig. 4a shows a steam pipe line station that utilizes centrifugal compressors. Steam for compressor drive is obtained partly from the high pressure main and partly from the exhaust of a main turbine which drives a generator for current production. With some types of drives, completely automatic control of the station is possible because centrifugals are capable of handling wide variations in load. Discharge pressures up to 300 psi can be obtained. The absence of rubbing parts reduces maintenance. All these features add up to fewer station operators and lower transmission costs.

Centrifugals for gas dehydration, Fig. 4b, used in conjunction with dehydrating coils and hydrocarbon refrigerants are often more economical than other methods. One bank of coils operates condensing while the other is defrosting. Hot gas from the compressor discharge produces the desired defrosting and the refrigerant provides the low temperatures necessary for gas condensation. Operation of these systems is usually quite satisfactory because the desired dehydration is readily produced and simply controlled. In some cases the savings in regeneration steam are sufficient to drive the compressor.

Liquid Gas Storage

Hydrocarbon refrigerants are well adapted to liquid gas storage cycles and to compression in centrifugal machines. Putting these two facts together, petroleum engineers developed a gas storage cycle that has proved to be quite successful. Use of hydrocarbon refrigerants in centrifugals have solved several additional operating problems that were always annoying in other types of compressors using standard refrigerants. Lubrication, suction gas superheating, gas steam contamination, and heat exchanger scaling problems have been reduced to the point where they can easily be handled without extensive outlays for equipment and manpower.

From the petroleum engineering applications discussed in this article, it can readily be seen that the centrifugal compressor is an important component of modern production facilities. Present day centrifugals are performing many other functions in gas recovery, chemical synthesis, low temperature refrigeration, and reaction heat control. With a basic knowledge of centrifugal compressor uses, the petroleum engineer is well equipped to handle many of the problems which arise in plant design, operation and maintenance. A succeeding article will discuss centrifugal compressor calculations and operating problems.

Part 2 of this two-part article will be published soon.

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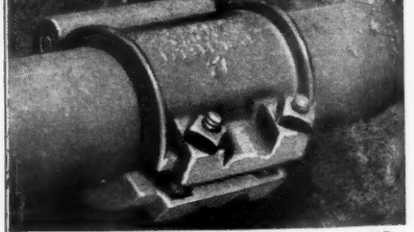

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The Technical Forum

Recycle Gasoline

Q **What is recycle gasoline?** *O. M. D.*

A Everyone knows that every simple substance, such as carbon dioxide, can exist in the three physical states; viz., gaseous, liquid, and solid. For a given weight of the substance, the particular state (or states) in which the substance exists, is determined by the pressure and the temperature. Such a system exhibits the generally known behavior of the critical state; i.e., that at a given maximum temperature, definite for each substance, the liquid state can appear at a certain minimum pressure. That means that at any higher temperature, none of the substance can be liquefied by increasing the pressure, even though the substance in the gaseous state can be made more dense (have a higher specific gravity) than the liquid is at the critical temperature.

These qualitative statements are applicable to all single substances. Owing to the wide diversity of properties of substances, covering the range from helium to uranium, the quantitative aspects of the various systems become quite complex.

Likewise, when mixtures of two or more substances are considered in the light of the critical conditions and those above and below the critical, the complexity only increases, and certain wholly new happenings appear. For example, the particular mixture of hydrocarbons that exists in condensate fields (some components of the mixture being gaseous when alone at the usual atmospheric temperatures and pressures, and some being rather high boiling liquids), are in the formation as a gaseous mixture above the critical temperature *of this mixture*. The pressure existing is usually quite high. As the hydrocarbons are produced, liquid is formed (surprisingly, even astonishingly, in the light of the qualitative statements made above) when the pressure of the mixed hydrocarbons is reduced. Reduction of pressure to 1800 or 1000 psig causes an increasing formation of liquid. Further reduction of pressure will effect a partial evaporation of already formed liquid. The scientist calls this behavior "retrograde condensation." Practically, recognition of the conditions controlling the behavior, leads to the most economical recovery of such liquid oil.

After effecting the separation of liquid by reducing the pressure of the produced flow, separation of the still highly compressed gas from the liquid and reinjection of the gas into drive wells maintains the formation pressure or reduces the rate of its decrease. In this way, separation of liquid by pressure reduction in the formation is prevented or greatly delayed. This operation is named recycling production. Gasoline so produced is naturally called recycle gasoline.

W. F. Faragher.

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This Forum is a meeting place each month for engineers, technologists, students, operators, etc. Each may profit by answers to his own knotty questions and those of others. Answers are supplied by the leading scientists and engineers in the world of oil and gas. Address all questions to

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Send them in right away while you think of it.

Cleaning Heat Exchangers

Q **What are the operating procedures and reagents, conditions, and method for cleaning heat exchangers and their tube bundles, internally, in a service where heavy thermally cracked bottoms are on the shell side and where temperatures are as high as 875 F?** *M. K. C.*

A There are many factors of a variable nature that must be taken into consideration when attempting to clean heat exchangers, "in place", under the above mentioned conditions. Where reasonable doubt as to the exact chemical nature of the fouling deposits exists, small scale laboratory tests should be performed to determine the degree of effectiveness of the cleaning materials available, simulating actual plant conditions as nearly as is possible.

Where heavy, thermally cracked bottoms have been on the shell side and fouling deposits have accumulated at approximately 875 F, the cleaning problem will usually prove complex and possibly call for the application of cleaning materials in the following sequence:

If heavy carbonized soil particles on the shell side are bound together by petroleum residues that will react to solvent-type detergents, lowered surface tension may be secured and a basis for future emulsification created. Following this solvent "presoak", removal of oil-bearing soils may be accomplished by circulating a heavy-duty alkaline type detergent at near boiling temperature. Upon completion of the "cleaning" cycle, the equipment should be thoroughly rinsed with clear water. If it then appears, or it is known, that iron oxide or limescale is adhering directly to the metal surfaces, this debris may be removed by circulation of an acid-type cleaner, properly inhibited

against attack on the steel surfaces of the equipment. Upon completion of the descaling procedure, good practice calls for an immediate fresh water rinse followed by circulation of an alkaline solution for surface neutralizing purposes.

Depending upon the nature of the deposits and how long they have been permitted to accumulate, recent field trials have produced occasional encouraging results for cleaning heat exchanger tube bundle interiors; the cleaning procedure being essentially that mentioned above.

From the overall standpoint, no general answer of a positive nature can be given to assure that the desired results will be consistently secured under all conditions. Rather, each case must be considered individually, taking cognizance of the many variables that enter the refining procedure, the chemical constituents that make up the soil pattern, etc. In this respect, the advice of qualified technical representatives of reputable cleaning compound manufacturers will prove of invaluable assistance.

Vincent E. Bowes.

Cold Rubber Manufacture

Q (1) What are the essenital operating conditions—temperatures, pressures, concentrations of main constituents, catalysts, solvents of suspending liquids, reaction times, or flow rates for the manufacture of "cold" rubber? (2) What, briefly, is the function of carbon black in "cold" rubber synthesis; what types of black are best, and what specific properties make these types of black most efficient for these purposes?

N. C. R.

A (1) Cold rubber is now being produced at the rate of approximately 200,000 long tons per year by the copolymerization of butadiene and styrene in aqueous emulsion at 41 F. Typical polymerization conditions and recipe are tabulated below:

Polymerization Conditions

Temperature	41 F
Pressure	approx. atm.
Conversion	60%
Time	14 hr.

Polymerization Recipe

Butadiene	72 parts by weight
Styrene	28
Tertiary mercaptan	0.24
Cumene hydroperoxide, 100%	0.10
Water	180
Rosin soap, potassium	4.7
$FeSO_4$ .7 H_2O	0.14
$K_4P_2O_7$	0.167
KCl	0.5
KOH	0.10
Dextrose	1.0

The last five items comprise the "redox" activator. Its preparation and ripening or aging require careful control to secure high and reproducible activity.

Common practice is to charge all ingredients to the reactor except the cumene hydroperoxide and when the contents are at 41 F the hydroperoxide is added to kick off the polymerization. The reactor is refrigerated by circulation of a coolant such as methanol through its jacket. This removes the sensible heat introduced with the charge and the heat evolved during and by the polymerization reaction. Usually polymerization is stopped at 60 per cent conversion by the addition of a powerful inhibitor or short stop. The reaction mixture of latex and monomers is then stripped to remove unreacted butadiene and styrene which are recycled to the process. Some withdrawals of these stripped monomers must be made from time to time to purge from the system inerts brought to it as trace impurities in the fresh monomers. The stripped latex is then coagulated and the resulting rubber crumbs are washed, dried and pressed into bales. Sometimes the stripped latex is mixed with dispersions of carbon in water prior to coagulation and drying. This gives a rubber-black masterbatch in which the carbon black is thus finely dispersed in the rubber and avoids the mixing of dry black with solid rubber in the tire factory.

The importance of carbon black to butadiene synthetic rubbers is not always fully appreciated. Without carbon black or equivalent reinforcing agent this kind of synthetic rubber would lack the physical properties necessary to its present wide industrial use. This point is illustrated by the data below:

Perbunan was the German butadiene-acrylonitrile oil resistant rubber and Buna S was the German equivalent of GR-S. The channel blacks used in the above examples are inferior to the furnace blacks developed during and since the last war.

The justification for the added capital and operating costs to make cold rubber rests on the improved wearing qualities of tire treads made from it. It is generally agreed that cold rubber treads compounded with high abrasion furnace (HAF) blacks will show 20 to 30 per cent better wear than the best natural tread stocks will in hot weather when wear is most severe. Also under service conditions, cold rubber is probably somewhat superior to natural rubber in tread cracking and crack growth.

(2) Carbon black is not used in the rubber synthesis or polymerization but may be added to latex after the polymerization has ended. Since the value of carbon black rests upon its performance when mixed with rubber it is evaluated in rubber mixtures. There has been much work done on the relationship of the physical properties of carbon black, e.g., average particle size, shape, adsorptive capacity, and pH, to its performance in rubber but so far no widely accepted theory has been developed which will predict quantitatively from laboratory test data the performance of carbon black in rubber in factory processing and in transportation service. Such preliminary data may justify the costly full scale testing necessary to evaluate the carbon black as a prerequisite to its adoption in any large scale use.

Dr. J. H. Boyd.

EFFECT OF CARBON BLACK ADDITIONS IN VULCANIZATES OF NATURAL AND GERMAN SYNTHETIC RUBBERS

	Pure gum stock		Carbon black stock	
	Ultimate tensile strength, lb per sq in.	Elongation per cent	Ultimate tensile strength, lb per sq in.	Elongation per cent
Natural rubber	4125	710	5000	650
Perbunan	2130	900	5000	600
Buna S	—	—	4200	650

NGAA Sponsors Seminar for Oil and Gas Analysts

A two-day seminar for plant chemists, sponsored by the Natural Gasoline Association of America, is scheduled in the Texas Hotel, Fort Worth, March 15-16. Purpose of the sessions is to study current procedures and equipment for determining the constituents of natural gases and natural gas liquids by means of low temperature fractional analysis. The varied techniques of this important analytical method will be discussed in detail by such experienced authorities as Dr. Walter Podbielniak, Podbielniak, Inc.; D. E. Smith, Phillips Petroleum; Joe F. Wood, Skelly Oil; H. A. Montgomery, Warren Petroleum; H. H. Beeson, Magnolia; M. F. Wirges, Cities Service; J. L. Thompson, Lone Star Producing; E. H. Counts, Sinclair, and W. D. Asher, Atlantic Refining.

NEWS

NGAA To Hold 30th Annual Convention

W. A. Baden, president, Anchor Petroleum Corporation, Tulsa, Oklahoma will head the program committee for the 30th annual convention of the Natural Gasoline Association of America, scheduled in the Mayo Hotel, Tulsa, April 25-27. Announcement of the committee was made recently by NGAA president, James E. Pew, Sun Oil Company, Philadelphia. Other members of the group include: Robert Boykin, Fullerton Oil Company, Pasadena, California; Allen T. Givens, Coltexo Corporation, Monroe, Louisiana; H. W. Harts, Warren Petroleum Corporation, Tulsa; T. W. Legatski, Phillips Petroleum Company, Bartlesville; M. L. Mayfield, Hiwan Oil and Gas Company, Houston, Texas; Howard B. Shelton, Sohio Petroleum Company, Oklahoma City; Ben H. Williams, J. S. Abercrombie Company, Houston, and John F. Lynch, La Gloria Corporation, Corpus Christi, Texas.

According to Pew, the program will feature addresses by leading figures in aviation and in the oil preparedness organization at Washington.

New FCC Unit Design

Several new design features are announced for the 60,000 bbl per day Fluid catalytic cracking unit being built by M. W. Kellogg Company for Gulf Oil Corporation at the latter's Port Arthur, Texas refinery. The innovations have been developed for the two-fold purpose of reducing installation costs and to raise process efficiency. The new regenerator is designed to operate at temperatures higher than those employed in existing fluid units. This boosts efficiency by reducing the amount of catalyst circulated to maintain desired temperatures in the reactor, and also speeds up the regeneration of catalyst, the designers say. Special stainless steel standpipe is used in the regenerator to withstand the higher temperatures.

In the new reactor, the catalyst stripper is totally enclosed in the reactor vessel, a separate vessel placed inside and above the catalyst grid, necessitating less supporting steel than do outside strippers.

Also, the flue gas exhaust stack is supported on top of the regenerator, which requires less support steel than the older design where this stack was entirely supported separately. Also, the amount of piping needed is reduced considerably.

A special vent newly designed eliminates most or all the noise of venting the flue gas, a condition omnipresent in older unit designs. Another interesting item in the new design is the fact that circulation of smaller amounts of catalyst reduces the size of the catalyst conveyor units, an important cost item.

B. of M. and API Release Motor Gasoline Survey

The octane ratings of motor gasolines sold at United States filling stations reached a new all-time high last summer, Secretary of the Interior Oscar L. Chapman announced in releasing the summer 1950 semi-annual survey made by the Bureau of Mines in cooperation with the American Petroleum Institute.

Latest of a series of surveys made by the Bureau in cooperation with the API, the report shows that when American motorists filled their tanks last summer, the octane ratings of the gasoline they bought were one and a half to two points higher than during the preceding summer and one point higher than during the winter of 1949-50.

Premium-price motor fuel had average octane ratings of 90.0 by the research method and 82.0 by the motor method. Regular-price gasoline had average octane values of 83.5 by the research method and 78.2 by the motor method. A free copy of report of Investigations 4765, "National Motor-Gasoline Survey, Summer, 1950" may be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pennsylvania.

Chemical Fertilizer Uses Refinery Waste Products

An improvement project that turns two refinery waste products into a chemical fertilizer has been completed at a cost of over $250,000 at the General Petroleum Corporation's Torrance, California, refinery.

The project involves a new process, conceived and developed by General Petroleum engineers and chemists upon which patent applications are pending. It produces eleven tons daily of ammonium sulfate, a nitrogen-bearing chemical used by California farmers for soil fertilization.

The new process begins with waste refinery gases, which are bubbled through sulfuric acid sludge, producing a solution of ammonium sulfate. This liquid is piped to another vessel, which turns it into crystal form by partial evaporation of the brine. The resulting ammonium sulfate crystals, which contain over 20.9 per cent nitrogen, are then separated by a centrifuge and are blown into a hopper.

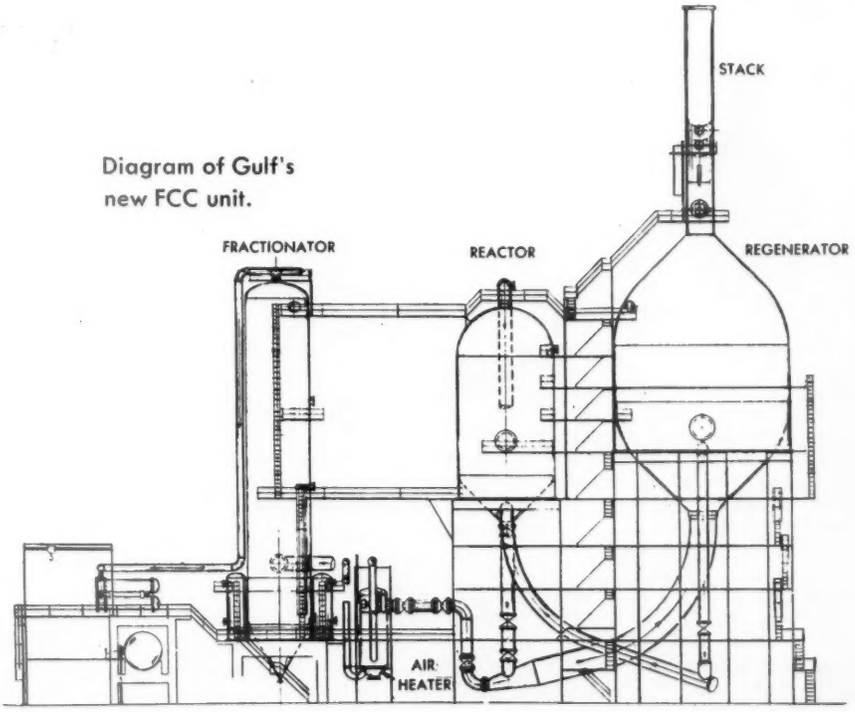
The new unit was engineered and constructed by The Fluor Corporation, Ltd., Los Angeles.

LPG Commission Favored

A bill has been introduced to the Texas Senate for establishment of a new liquefied petroleum gas commission to take over control of butane gas operations in Texas.

The bill, introduced by Senator Gus Strauss, would create the new commission of three members, appointed by the governor for 6-year terms. Members would serve without pay except for $10 a day expenses for meetings.

Diagram of Gulf's new FCC unit.



New Cat Cracker Unit At Salt Lake City Refinery

A new 13,000 bbl per day Houdriflow catalytic cracking unit is now in operation at the Salt Lake City, Utah, refinery of the Salt Lake Refining Company, Brigadier General D. N. Hauseman, President of Houdry Process Corporation announced. The new installation is the largest Houdriflow unit to go on stream to date and is circulating catalyst at the rate of 300 tons per hour by means of the new gas-lift. The use of the gas-lift eliminates catalyst flow limitations formerly encountered with elevators on TCC units. At higher catalyst circulation rates, a wide range of catalyst/oil ratios are possible in the Houdriflow process, which increases the operating flexibility and permits liquid feed stocks to be charged without vaporization. Another advantage coming from the gas-lift is a major simplification in the kiln, making it possible to superimpose the reactor and kiln, which means that the catalyst is lifted only once. Such simplifications in design have resulted in a considerable reduction in investment, maintenance and operating cost.

In addition to the Salt Lake unit, 5 Houdriflow units have been in operation in the U. S. since early 1950.

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Removing heat exchanger bundles

New Method For Removing Heat Exchanger Bundles

The development of a new method of removing exchanger bundles, which results in lower initial investment for supporting structures in processing plants, has been announced.

According to the M. W. Kellogg Company, refinery and chemical engineers of Jersey City, New Jersey, bundles in shell and tube heat exchangers may now be removed by the special exchanger jack, shown in accompanying photo. It has been designed by this engineering firm to save construction costs, for exchangers supported above the ground, by eliminating conventional pulling beams and their related structures.

Other economic advantages include the fact that this improved bundle remover may permit a more compact general plant layout and thus a smaller plot. Furthermore, exchanger supports themselves may be made somewhat lighter as they need not be designed to resist the stress of conventional bundle removing arrangements.

The tube bundle removing device is portable and consists of a modified commercial center-hole hydraulic puller. It has an extensible, jointed ram and an adjustable yoke to transmit force against the bonnet end shell flanges of exchangers of various sizes. The device can exert a push on the tube bundle up to 12,000 lb for a maximum distance of 16 ft, permitting the removal of dirty bundles that could not be pulled by usual means.

New Record Output

A new production record has been set by the Torrance (California) refinery of the General Petroleum Corporation. For the week ending January 25, the refinery processed an average of 130,262 bbl of crude oil each day. Of this crude oil 125,670 bbl per day were charged to the refinery's crude distillation units, which have a rated capacity of 100,000 bbl daily. The remaining 4592 bbl were heavy crude oil and were charged to what is normally a secondary processing unit.

Blaw-Knox To Employ Socony Patent Processes

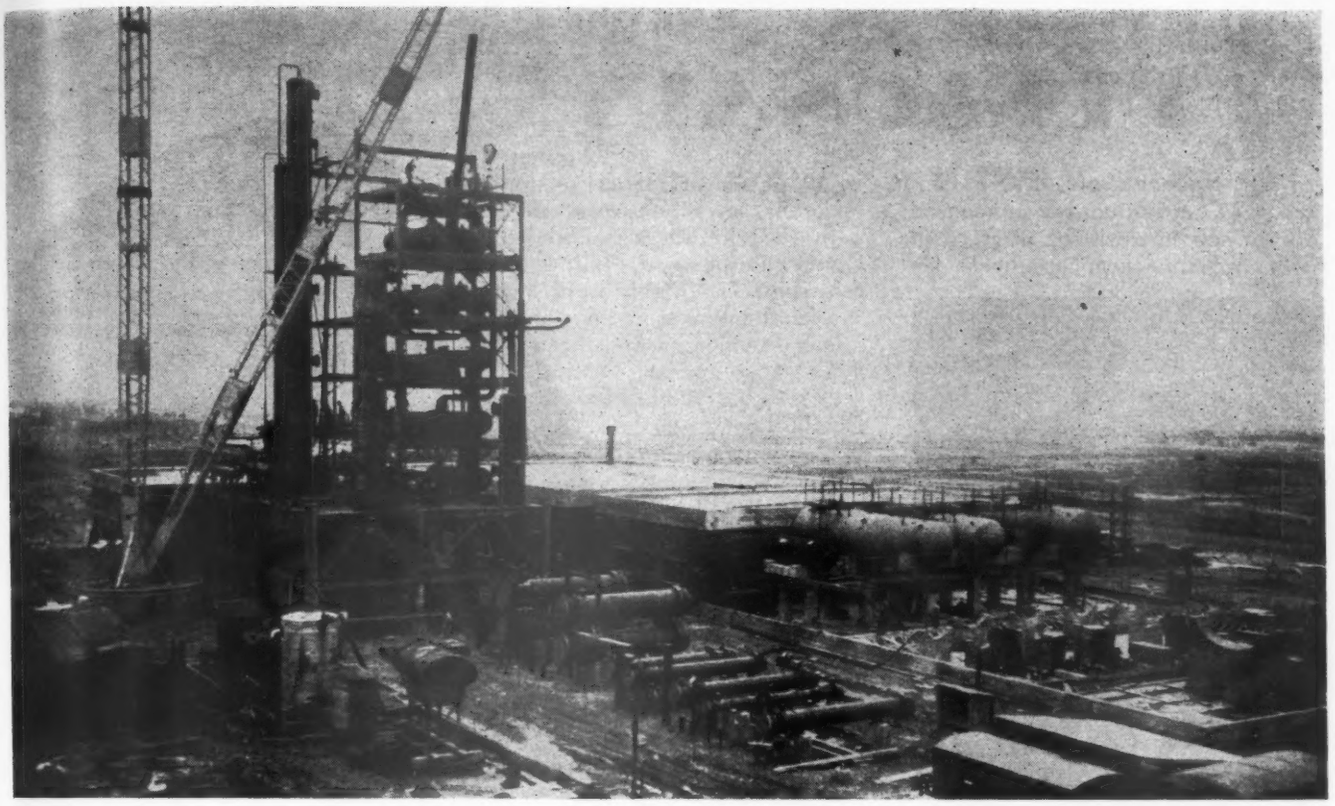
Chemical Plants Division of Blaw-Knox Company has been authorized under the licensing program of Socony-Vacuum Oil Company, to design and build catalytic cracking plants using the latter company's patented processes. Included in these processes is Thermofor catalytic cracking, a modern development in oil refining designed to enable octane improvement and higher yields.

Cities Service To Install Grease-Making Facilities

Cities Service Oil Company (Delaware) will install grease-making facilities at its Chicago, Illinois, terminal and compound plant capable of producing 8,500,000 lb of grease per year, according to an announcement by A. W. Ambrose, president.

The grease-making facilities represent the second phase in a step-wise program to make the Chicago plant an integral source for both lubricating oils and grease in the Great Lakes area. Southwestern states are supplied from the company's Ponca City, Oklahoma, refinery and compound plant.

The Chicago compound plant was completed last year and provisions were made in the initial building to house a grease plant. A modification of the Stratco process will be used in the new grease-making facilities. Although the rated capacity will be 8,500,000 lb annually, peak loads representing 150 per cent of capacity will be possible for short periods.



Societe Industrielle Belge des Petroles at Antwerp, Belgium on its way toward completion. It is expected to be in operation toward the end of this year.

Belgian Refinery Nears Completion

Scheduled to be in operation toward the end of 1951 is the new 30,000 bbl per day refinery being constructed for the Society Industrielle Belge des Petroles at Antwerp, Belgium by Kellogg International Corporation.

As part of the over-all industrial expansion in Europe, the new plant, financed by Belgian and British interests, will utilize normal refining processes and will have facilities for operation as a completely integrated refinery.

It is situated on a site adjacent to the Scheldt River. Extensive development work is being undertaken by the Port of Antwerp to improve facilities for ships that will bring in crude.

In planning the refinery, sufficient space has been provided for the future addition of process units to produce additional products such as lubricating oils and higher octane gasoline.

Thiophene In Synthesis Gas

A procedure for determining the presence of thiophene, an organic sulfur compound, in synthesis gas containing low amounts of unsaturated hydrocarbons is described in a report released today by the Bureau of Mines, Department of the Interior. Prepared by H. W. Wainwright and G. I. Lambert, Bureau chemical engineers at the Morgantown, West Virginia, Synthesis Gas Production Branch, the report describes the experimental investigations and various phases of the procedure, and includes graphs showing the effects of different compounds used in the tests.

A free copy of Report of Investigations 4753, "A Colorimetric Method for the Determination of Thiophene in Synthesis Gas," may be obtained by writing to the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Penna.

New Technical Program

A new American Society for Testing Materials' technical committee has been organized to work on the formulation of methods of atmospheric sampling and analysis, the selection of acceptable nomenclature and definitions, and the stimulation of research to accomplish the foregoing purposes. The group held its first organization meeting at the headquarters of the ASTM recently and elected the following officers: L. C. McCabe, chief, office of air and stream pollution, U. S. Bureau of Mines, chairman; F. S. Mallette, American Steel and Wire Company, vice chairman, and H. S. Schrenk, research director, Industrial Hygiene Foundation of America, Inc., secretary.

ECA Funds Will Help Build German Refinery

A new refinery is to be built at Lingen, in the Emsland, Germany region, with ECA funds totaling $670,000. The money will be spent in the USA on refinery equipment not obtainable in Germany. Total cost of construction will be DM 36,000,000. It is scheduled for completion in 1952.

Annual production is estimated at 600,000 tons, of which 320,000 tons will be gasoline. Fifty thousand tons will be diesel oil, 22,000 tons, kerosene, and 100,009 tons of coke, the remaining 108,000 tons being made up of liquid gas, fuel gas for refinery consumption, and potential losses. At the present time the Emsland region produces about 45 per cent of Western Germany's crude oil, and by 1952 it is expected to yield about 1,100,000 tons of crude oil out of a total estimated German production of 2,000,000 tons.

Baghdad To Get Refinery

The National Bank of Iraq has agreed to provide £2,000,000 sterling towards a £5,000,000, sterling oil refinery to be built near Baghdad. According to a report from Reuter the balance will be provided by the Government. The refinery is expected to produce 3200 tons of refined spirit daily.

—PERSONALS—

P. C. Spencer, president of Sinclair Oil Corporation, has announced Sinclair activities will be enlarged in the petroleum chemicals field. He

John A. Scott

stated that a newly created and staffed petroleum chemicals division had been set up by the company. Initially, the new division's efforts will be devoted to specialized petroleum fractions and petro-chemicals now manufactured, such as aromatic solvents, lubricating oil additives, demulsifying agents, and sulfonates.

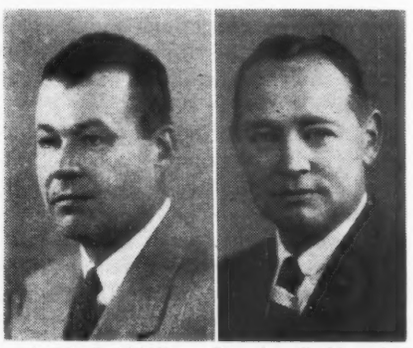
Heading the new division is **John A. Scott,** who joined Sinclair in 1934 as a chemical engineer in the research and development department at East Chicago, upon graduating from the University of Minnesota with a degree in chemical engineering. In 1944 he was transferred to Sinclair's Corpus Christi refinery, where he worked on the design, construction and initial operation of the alkylation unit. In 1945 he went to New York as assistant to E. W. Isom, vice president in charge of research and development, the position he held until his present appointment.

F. M. Files has been appointed superintendent of the Northwest division of Phillips Petroleum Company's refining department. Files replaces **J. W. Loy,** who has been given a temporary leave of absence by Phillips for work with the Petroleum Administration for Defense in Washington, D. C. Files joined Phillips immediately following his graduation in 1930 from Austin College, Sherman, Texas. Beginning as a chemist at the Borger, Texas, refinery he gained experience in all phases of refinery operations, including several research projects.

In 1941 he was transferred to the Bartlesville office of Phillips as process engineer. In this work he gave special attention to various phases of refinery economics and the improvement of operations. During World War II he was closely associated with the Phillips' extensive aviation gasoline production program.

Max A. Minnig, manager Witco Chemical Company's carbon black division at Akron, Ohio, has been named special assistant to the president in all carbon black matters. In addition, he has been elected vice president of Witco Chemical Company in charge of Witco's carbon black division. He will shortly make his headquarters at the company's offices at 295 Madison Ayenue, New York City. Minnig received his education at the University of Oklahoma where he graduated in 1940.

Louis B. Wells has been appointed to the newly created position of manager of Sun Oil Company refineries. He has been manager of Sun's Marcus Hook refinery since May 1949. **Charles E. Maschal** was



Louis B. Wells Charles E. Maschal

named to succeed Wells as manager of the Marcus Hook refinery. Maschal has been assistant manager since May 1949.

Wells began work at the Marcus Hook refinery in 1923. He was named assistant superintendent in 1933, became refinery superintendent in 1944, and was appointed refinery manager in May 1949.

Maschal joined Sun Oil at the Marcus Hook refinery in 1933. He served as a technical engineer from 1934 until 1939 when he was named an operating assistant. He became an assistant superintendent in 1944, administrative assistant superintendent in 1947, assistant manager in 1949.

Dr. M. E. Spaght

Dr. M. E. Spaght has been elected to the board of Shell Chemical Corporation. Spaght is president of Shell Development Company and brings to the board many years executive experience in the field of petro-chemical research. Holder of degrees in chemistry from Stanford University and a former student at the University of Leipzig, he has been with Shell since 1933.

Joseph E. Carney has been appointed assistant chief metallurgical engineer of Sun Oil Company. Carney joined the Sun Oil metallurgical department at the company's Marcus Hook refinery in May, 1934, and was named chief inspector of the department about 10 years ago.

He received a B. S. degree in chemical engineering at the University of Pennsylvania in 1928 and worked for the Midvale Company in various engineering capacities before beginning his career with Sun.

C. P. Baker, manager of Socony-Vacuum Oil Company's East St. Louis, Illinois, refinery, has been elected president of the East Side Associated Industries. The election took place at the annual meeting of the association recently.

E. H. Barlow, of Standard Oil Development Company, New York, has been appointed chairman of the American Petroleum Institute's committee on liquefied petroleum gas for 1951. **E. O. Mattocks,** of the American Petroleum Institute, was named secretary.

Dr. Sol Weller, formerly of the U. S. Bureau of Mines, Pittsburgh, Pennsylvania, has joined the staff of Houdry Process Corporation, Marcus Hook, Pennsylvania, as senior research chemist.

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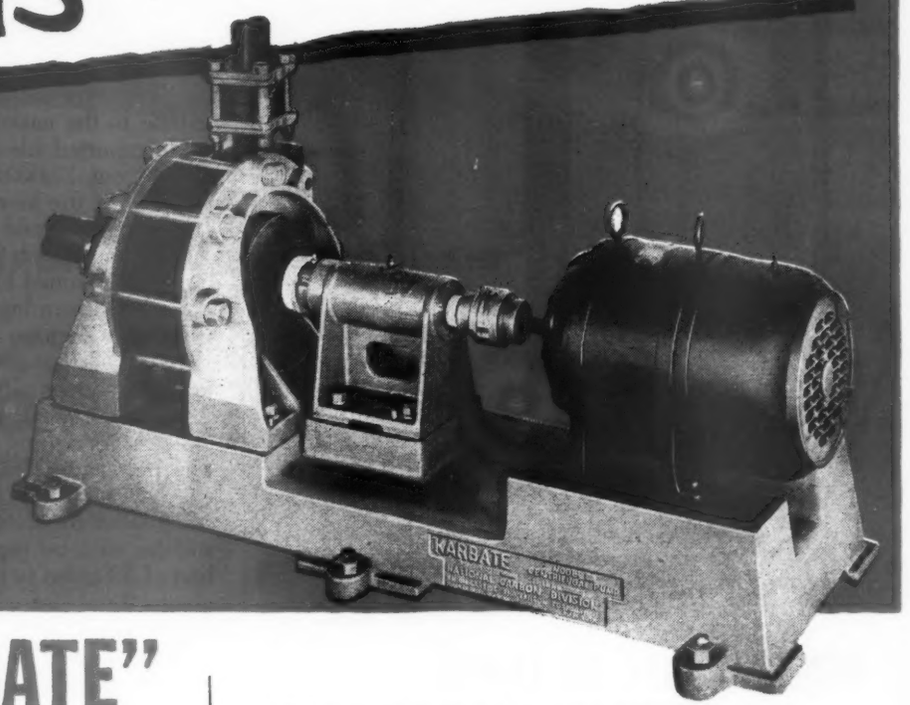

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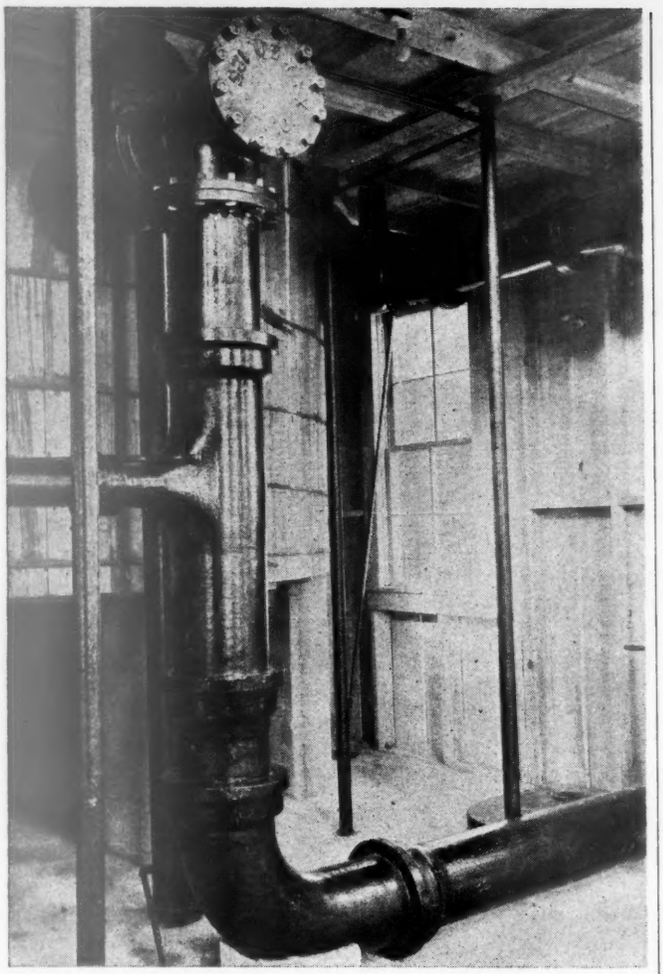

DIRECT ROUTE TO LOWER PLANT MAINTENANCE

The direct and indirect expense of replacements of short-lived refinery pipe lines can be reduced, or avoided altogether, by the use of cast iron pipe. This has been proved by many refineries whose maintenance costs have been lowered by replacing other pipe materials with cast iron.

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PAD Urges Use of Refineries' By-Products

Responding to a recent request by the Petroleum Administration for Defense, for increased emphasis on by-products of the nation's oil refineries, many companies are building or planning projects that will increase output of scarce but vital raw materials. Two such projects have been announced by Standard Oil Company of California and Gulf Oil Corporation.

Standard of California announced that it will build a benzene plant costing in excess of $10,000,000 at its El Segundo refinery in Southern California. The announcement was made by T. S. Petersen, president of the company, who stated that designs for the new facilities already are under way, and that the plant should be in operation by mid-1952.

"Completion of this project will substantially increase the refinery's output of aviation gasoline, as well as contribute to the nation's need for benzene," Petersen said.

He reported his company's new plant is being designed to turn out 13,000,000 gal of benzene annually, about 15 per cent of the increase asked of the oil industry by PAD. It also is designed for daily manufacture of 3200 bbl of toluene, for which there is an urgent need in aviation gasoline. The planned El Segundo facilities will be built around a new platforming process developed by Universal Oil Products Company.

Gulf Oil has announced that it will build the world's largest single unit for manufacturing ethylene at Port Arthur, Texas. Ethylene is a gas used extensively as a raw material in making chemicals valuable for national defense. The new facilities will produce nearly 2½ billion feet yearly, increasing total U. S. production of this chemical component by about 12 per cent. Included in the project will be an 8-in. pipe line 76 miles long, and a 6-in. pipe line of 32 miles to transport the gas to Gulf Coast chemical plants. Total cost will be in the multi-million dollar bracket, but no exact figure was disclosed.

Ethylene will be made from by-product gases produced in the refining processes at Gulf's Port Arthur refinery. These gases are at present used principally as fuel for the plant's various operations. Occupying about two acres of the refinery property, the ethylene plant will comprise a series of fractionating towers for separating ethylene, ethane, and other hydrocarbons from refinery gases, and a series of cracking furnaces for converting the ethane to ethylene.

Construction will begin within two months and is scheduled for completion within a year after breaking ground. Building contract has been let to The Lummus Company.

Also at its Port Arthur refinery Gulf will add additional equipment for the production of 9,000,000 lb per year of iso-octyl alcohol, which is used extensively by the chemical industry in the manufacture of vinyl plastics. Facilities are expected to be in operation by the end of 1951.

B. of M. Studies New Process for Gasifying Coal

Pilot plant experiments have indicated a new process for making synthetic gas for synthetic fuels directly from coal may be developed soon, the United States Bureau of Mines has reported. Synthetic gas, which is carbon monoxide and hydrogen, can be used in the synthetic production of gasoline, oil, pipe line gas, ammonia, alcohol, and other products, and is produced by converting coal into gas. Tests for gasifying raw coal are under way at the Bureau's plant at Morgantown, West Virginia in cooperation with West Virginia University.

The Bureau of Mines reports that the process produces gas from pulverized coal with the aid of oxygen and steam. Regional Bureau Director M. P. Greenwald stated a new gasifying plant will be built at Louisiana, Missouri, incorporating many of the features developed at Morgantown.

Meetings For Pipeliners

With what might be termed the spring convention season getting under way, it may be appropriate to call attention to those that are of particular interest to pipe line men. Actually, the year has already seen two very excellent industry meetings held, that of the Pipe Line Contractors Association at Houston in January, and the short course sponsored by the Tulsa Section of the National Association of Corrosion Engineers, held late in February. The latter met for the first time last year. Designed as a practical course for foremen, superintendents, engineers, and inspectors, 178 enrolled for the school, a surprising number for a first-year meeting.

What does this leave for the remainder of the spring months?

In chronological order there is the annual meeting of the National Association of Corrosion Engineers in New York City, March 13 through 16. Begun many years ago exclusively as a pipe line organization, this association now embraces numerous industries — any that has corrosion as a problem. Regardless of its wider scope, the pipe line industry still forms its nucleus and the interest of its members is as great as ever — attested to by the number that attend the annual meeting and the several regional meetings throughout the year.

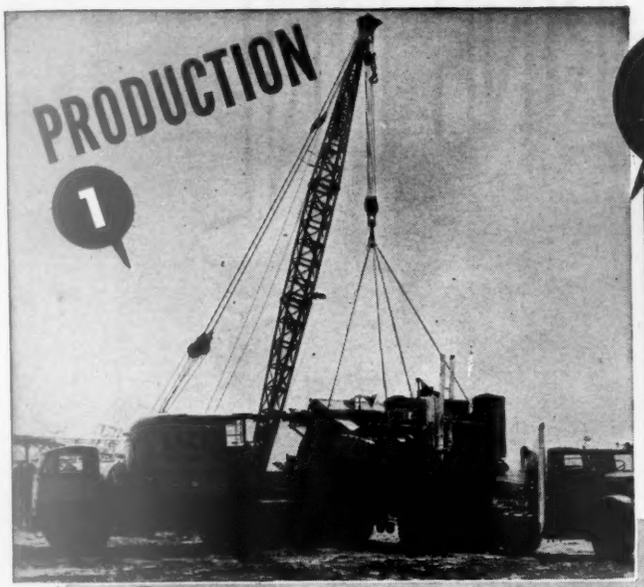
At the University of Oklahoma in Norman each year is held the Southwestern Gas Measurement Short Course. For those interested in gas measurement this has become the focal point where one can be kept up-to-date on new metering equipment and methods. The classes are always conducted by leaders in the industry whose knowledge and approach are of a practical nature. This year the meeting will be held on April 10, 11, and 12.

The Petroleum Industry Electrical Association always presents an excellent program for those in the pipe line business who are concerned with communications and electrical matters. Although a copy of the 1951 program is not yet forthcoming, it would be a safe wager to say it will live up to past standards. This meeting is April 17, 18, and 19 in Dallas, Texas.

Last year at Galveston the Transmission Section of the Southern Gas Association held its first session as a separate and distinct group. The two afternoon meetings by this group were well attended and the interest high. It is to continue as a part of the annual meeting of the association and should be conducive to gas pipeliners attending in even greater numbers. The meeting this year will be at Biloxi, Mississippi, April 23, 24, and 25.

Another gas association that always has a place of importance on its program for those in the pipe line end of the business is the American Gas Association, Natural Gas Department. Meeting in Dallas, Texas, May 7 and 8, it already has been announced that a program is being planned that will consider some of the most important problems facing the industry, and that the speakers will be chosen from among the most outstanding men in their fields.

Pipeliners, no matter what their specialties, should find one or more of these meetings of particular value.—F. H. L.



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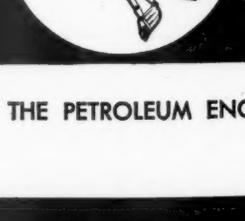

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P 615.635

Electrical Resistivity of Coatings

WALTER F. ROGERS

A Study Made of Seven Methods of Measurement to Determine Which Is Considered the Most Practicable

At the conclusion of the API[1] tests on pipe line coatings in 1940 the pipe line industry felt that the problem of designing coatings had been thoroughly investigated and the status of the art raised to a desirable position. In general, the results of the tests showed the rate of pitting to be inversely proportional to the thickness of the coating. Largely eliminated as unsuitable were single coats of paint with a dried film thickness of 1 to 3 mils, as well as the single coat greases, asbestos filled or emulsified materials applied in a single coat with heavy bulk volumes of 3 to 30 mils final coating thickness. The standard pipe coating became coal tar or asphalt enamels, which, when applied as a single flood coat over a primer and followed by a spiral wrap of asbestos felt, has a thickness of approximately 90 to 120 mils. From this basic type coating variations have been developed consisting of multiple wraps of asbestos felt or open woven reinforcing materials of the glass fiber type, together with intermediate layers of asphalt or coal tar type enamels.

Today many variations in pipe coating practice exist even though the materials of construction are relatively few. These are variations in the number of coats of enamel and wrapper used, whether the pipe is hand or machine coated, whether the coating is yard or field applied, and whether or not it is holiday inspected and repaired at the time of burial. Each of these factors has an important bearing on the condition of the pipe coating when laid and the service it will give.

At the time the API tests were completed and the present use of enamel type coatings begun, the use of electrical protection to prevent corrosion was in its infancy. The development and increased use of this protection with coatings has forced a modification of the original conclusions as to what constitutes the most valuable property of a pipe line coating. Electrical protection is applied to coated pipe to flow current to the bare pipe areas where the coating has become broken or distorted. In addition, current is required for the coated areas as regulated by the conductivity of the coating.

With the advent of electrical protection the protective value of a coating is no longer a function only of the coating thickness, but is a function of the electrical resistance also, i.e., the greater the electrical resistance of the coating the lower the amount of current required for protection and the lower the cost for installing the electrical equipment.

Where electrical protection is put "on top" of a pipe coating the total cost of protecting the line becomes the combination of the two. With such a combination it is advisable to evaluate coating thickness in terms of resistivity so that the cost of providing varying quantities of electrical current can be equated against the cost of the pipe coating thickness that results in that quantity of current. In short, the greatest amount of electrical resistance should be obtained per dollar invested in the pipe coating.

In order to determine this desired value it becomes necessary to evaluate the effect of the various factors affecting the resistance of pipe coatings with time, i.e., thickness, multiple wraps, hand or machine applied, etc. The best method of doing this is to select coated areas where different methods of applying different pipe coatings have been used and determine the coating resistance with time until no further changes are obtained.

This requires the use of a method for determining accurately the pipe coating resistivity in the field with a minimum amount of time and labor. There have been several methods presented for measuring coating resistivities, but it is felt that a discussion of them is in order to show the theory involved, the apparatus required, and the speed of measurement to facilitate the gathering of this type information. It is the writer's opinion that the pipe line industry has been lax in this method of evaluating coatings as an aid in obtaining maximum economic value.

General Theory

The general procedure involved in measuring the resistance of a pipe coating is to so connect a source of power that a current flows from a ground bed through the soil to the coating, to the metal pipe upon which the coating is applied, thence through connecting wires back to the power source. The voltage drop $\triangle E$ across the coating is measured, as is the current, I, which flows through the area of coating, XA. The resistance of the coating, C, in terms of area is then calculated by Ohm's Law:

The Author

Walter F. Rogers

Walter F. Rogers, a native Texan, was graduated from the University of Pittsburgh in 1926 with a B S in chemical engineering and received the professional degree from Pittsburgh in 1934. He began work as chemical engineer for the Gulf Refining Company, Port Arthur, Texas in 1926. In 1927 transferred to the Gulf Production Company, Houston, to study oil field and pipe line corrosion problems under a fellowship of the Mellon Institute of Industrial Research. In 1948 he was made chief chemist of the Houston Production Division Chemical Laboratory of Gulf.

Rogers has studied pipe line and producing corrosion problems, and oil well drilling fluids extensively. Has written a number of papers on corrosion and is the author of a book on oil well drilling fluids.

EXCLUSIVE

$$C = \frac{\triangle EAX}{I} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where:

C = ohms per square foot
△E = volts
I = amperes
A = square feet per lineal foot of pipe
X = lineal feet of pipe.

It is a simple matter to measure the voltage drop through the coating but it is a more difficult matter to measure the current that is picked up by a unit area of pipe buried in the soil. This results from the fact that the quantity of current picked up per unit length varies from length to length. This is illustrated in Fig. 1, which shows the manner in which current fans out from an anode to a buried long metallic structure. It is this inability to calculate easily from a knowledge of the total anode current the quantity each square foot of pipe is picking up that causes the greatest difficulty in measuring pipe coating resistivities.

In the discussion that follows, two units of coating resistance will be used. These are:

C = ohms per square foot
K = ohms per lineal foot of pipe.

Where:

C = KA

It must be recognized that the electrical resistance of the soil in which a coating is buried plays an important role in the resistance of the coating. It is necessary, therefore, for a measure of the soil resistance to accompany the coating resistance to enable comparisons to be made between different geographic locations. All coatings absorb moisture to a certain degree. A decline in resistance is the result of continued water absorption, plus the growth of holidays in the coating through soil stress, loss of adhesion, etc. The measured resistance, R, can be considered as the result of an equivalent exposed area in an environment of a certain resistance, or:

$$R = \phi\left(\frac{\rho}{A}\right) \quad . \quad . \quad . \quad (2)$$

which states that the coating resistance is a function of and directly proportional to ρ, the resistance of the soil electrolyte, and inversely proportional to A, the equivalent exposed area.

This means that if two coatings with equivalent bare areas are exposed in two soils with resistivities of 10,000 ohm-cm and 1000 ohm-cm, respectively, the measured resistance, R, will be 10 times as great in the first case as in the second. Thus, while the coating had the same degree of breakdown in each case, it would apparently be in better condition in the high resistance soil unless the difference in soil resistance is taken into account.

Equipment Required

A. *Source of power and ground bed.* The current required for measuring coating resistance may be obtained by a variety of methods. The power source as well as the size of the ground bed is dictated by the amount of current used. It is of considerable importance that the measuring method be one that requires a small amount of current, which will result in a minimum amount of equipment to be carried to the field.

A portable source of current is obtained through the use of heavy duty 22.5-45-volt B batteries. The maximum short time current drain that should be expected per battery is about 2.5 amp. Such high voltage for low current is dictated by the use of probe bars for ground beds. In order to prevent wastage of time and effort it is desired that a minimum in men and equipment be required. It has been found that two men can carry at one time all the necessary equipment, provided not more than 2 such batteries and 2 probe bars, (5/8 in. by 5 in. octagon bars or 2-in. soil augers) be used for the power set up. The bars may easily be pushed or screwed into the ground and the circuit resistance governed by the area of the bar-ground contact. Usually two such bars are used, and by having them 20 ft apart the second bar will decrease the resistance given by the first about 50 per cent.

Where a current source of not more than 5 amp is sufficient the use of this system has been found to give satisfactory results.

Where sacrificial anodes are along a line it is sometimes possible to use their current output to measure the coating resistance. In such cases the output is usually not more than 0.200 amp per anode, yet this may be sufficient and no additional power equipment needed.

If a current over 5 amp is required it is necessary to go to heavy power equipment. If the work is to be done along a cathodically protected line the rectifier in use will normally provide 10 to 100 amp. In this case no additional or supplementary power source is necessary. If no such power source is available it is necessary to move a welding machine to the test location. In this case it is also necessary to install a substantial ground bed. A ground bed consisting of 10 ft of 6-in. pipe with a 40-volt generator will usually give a maximum of about 20 amp. The use of a power source of this type increases the cost of the measurements as only one such ground bed can be put in per day at the expense of a truck, gang, and welder.

B. *Potential and current measuring instruments and reference elec-*

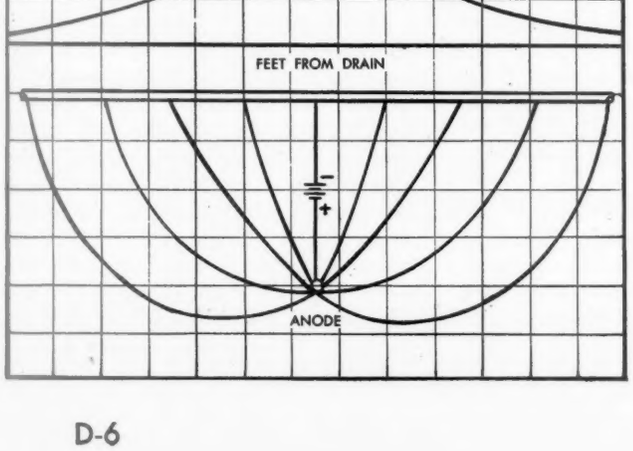
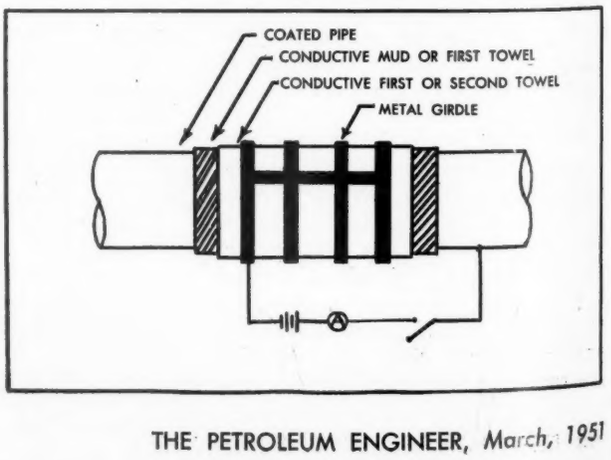


FIG. 1. Current distribution on pipe from point anode.

FIG. 2. Arrangement of equipment for pattern resistance method.



trode. A measure of the pipe-to-soil potential is essential in every case. Popular and adequate types of instruments for this work are:

1. Potentiometer
2. High resistance voltmeter
3. Rhodes potentiometer-voltmeter
4. Vacuum type voltmeter.

The potential meter should have a minimum sensitivity of 1×10^{-4} volts and should be readable to the third place. A potentiometer makes a desirable instrument because it draws no current at balance and is not subject to potential drop errors resulting from high electrode contact resistance. A pipe line potentiometer is manufactured by Leeds and Northrup Company, Philadelphia, Pennsylvania, which has a range from 0 to 4 volts with multidials for 0-5 mv, 5-100 mv, and 100-1000 mv, and is a suitable type instrument for this work.

Any voltmeter type instrument should have high resistance characteristics to prevent instrument errors due to high electrode contact resistance. A generally accepted requirement for this work is 1×10^4 to 1×10^6 ohms per volt.

An ammeter is required with all the methods discussed. This should be a rugged, accurate instrument. A desirable instrument has two ranges, 0-1 and 0-10 amp. It should be readable to 2 per cent or less of full scale value.

A copper sulfate electrode is used as the normal reference electrode. These are commercially available from the many companies catering to the electrical protection business. One popular size is approximately 1 in. in diam and 6 in. long.

C. *Probe and contact bars.* For use with copper sulfate electrodes, sturdy probe bars are required for pushing through the soil cover and contacting the pipe. The same size and design of rod can also be used as a ground bed in connection with batteries to supply current to the pipe. Similar sharp pointed bars are used to contact the pipe for the return circuit to the battery. Such latter bars must be completely coated with tape, paint, or other insulating material so all the current will flow through the pipe coating to reach the line and not flow directly from the ground bed to the probe bar. A popular size bar for all these purposes is made of ⅝ in. octagon shaped steel. The length varies from 5 to 6 ft. A handle 14 in. long is formed at one end and equipped with rubber grips. The contact end is ground to a sharp point.

D. *Soil resistance.* The soil resistance should be measured in place at the time of the test. The resistance of a soil varies over a very wide range as the moisture content changes. It also varies locally both horizontally and vertically. It is, therefore, advisable to use a method that integrates the soil resistance over a relatively large area. If the soil resistance is not measured at the same time the others are made, measurement at a later date may provide erroneous information. Several pieces of equipment are available for measuring the soil resistivity in place. These are:

1. Megger, using the 4-electrode system; available from James G. Biddle Company, Philadelphia, Pennsylvania.

2. McCollum earth current meter[2], using the 4-electrode system.

Both methods permit, through variations in the electrode spacing along the ground surface, averaging soil resistance over a wide range.

3. Shepard canes[3]. This apparatus consists of two rods, each about 4 ft long with a metallic tip on one end and a handle on the other. The rods, except the metal tips that are used as anode and cathode, are insulated from metallic contact with the ground. In use the metal tips are pushed into the ground about 6 in. apart and a current caused to flow from a 3-volt battery through an ammeter from the anode to the cathode through the soil, and back to the battery. The probe points are calibrated for the spacing for which they are used and the ammeter calibrated in ohm-cm, the index of the soil resistivity.

4. Columbia rod type cane[4]. A simplified type of earth resistance probe can be constructed on a single bar in place of two used by Shepard. In this case the metal tip has a second band of metal about 1 in. above it and insulated from the tip. The tip and separate band are used as the cathode and anode. The remainder of the rod is insulated from the earth. In operation the bar is pushed into the ground until both anode and cathode are in firm contact with the soil. A current is then caused to flow from a dry cell through a milliammeter between the anode and cathode through the earth. The electrode assembly is calibrated in solutions of known strength so that the amperage that flows can be readily interpreted in terms of soil resistivity in ohm-cms or ohm-ft as required. This type rod has an advantage in that the entire assembly is mounted on a single shaft. In addition, the cell constant for the electrodes remains fixed because of their permanent mounting.

The disadvantage of the Shepard and Columbia type rods is that, because small electrode spacings are used, they do not integrate over so large an earth volume as do the 4-electrode methods. In addition, polarization errors may occur through the use of direct current, whereas the 4-electrode methods use alternating current through the ground circuit.

E. *Connecting wire.* A 10-ft double wire lead is required for connecting the copper sulfate electrode and pipe with the measuring meter. The wire ends should be equipped with battery clamps or other terminal pieces for making quick connections. A 110-ft rubber covered flexible cable marked at 25, 50, and 100 ft is necessary for measuring potential drops along the pipe for use with the current-voltage change method.

F. *Pipe line finder.* This piece of equipment is not a part of any of the coating resistivity methods but is absolutely necessary as a time saver.

Pattern-Resistance Method

The Pattern-Resistance Method was originally developed during the API coating tests for measuring both the number and location of conductance areas in a coating. The method is not strictly comparative in nature to the others discussed because it is restricted to samples that are exposed for measurement. The high cost of doing this for pipe lines in service makes its general use unacceptable in favor of more rapid methods. It is, however, in the long run perhaps the final and most conclusive test that can be made on a coating. The method is applicable not only to coated pipes of normal pipe line size, but also to small test samples of 1 or 2-in. diam by a minimum of 1 ft long.

The method is relatively simple and consists of surrounding the coating, which has been exposed and cleaned of dirt, with a conducting medium. There are several ways of accomplishing this but a simple one consists of wrapping several layers of cloth toweling around the coating and saturating it with salt water containing greater than 25,000 ppm sodium chloride. The width of the towel wrapping must be measured to calculate the area of coating contacted. Over the towel should be fastened a metal girdle that completely surrounds it, the accuracy of the measurement being dependent upon having a low circuit resistance outside the coating. If too little contact is obtained between the girdle and the towel the calculated resistance will tend to be high. A dry cell battery is connected through a milliammeter to one binding post on the metal girdle and to a C-clamp or other metal connection on the pipe. Where the resistance of the battery,

connecting wire, girdle, etc., is made properly low, the total voltage of the battery is considered as being across the coating. The resistance of the coating is then calculated by relation (1).

In using this method care must be taken that an average coating condition be examined, as an area with abnormally large breaks will lead to too low a resistance value for the average. It is usually advisable to expose 5 ft of pipe and make five separate measurements at 1-ft intervals. Examples of the results obtained by this method may be found in the API[5] coating tests. Fig. 2 shows a drawing of the apparatus involved in the measurement.

Isolated Area Test

Testing by the Isolated Area Method is reserved for those coatings that are applied to electrically isolated sections buried in the soil, or to coatings on pipe lines that have been set apart electrically from the remainder of the line by means of insulated flanges or joints. These limitations cover an extremely wide range of pipe sizes and lengths.

One general case of an "isolated area" is found where relatively small sized sections of pipe, usually 1 or 2 in. in diam and from 1 to 5 ft long, are coated with test materials and buried in a location such as a laboratory soil box or at a test burial site for study of the underground performance. In such cases the ends of the pipe must be capped so that no current flow can enter the pipe through contact of the soil with the bare interior. Where such coatings are to be studied electrically it is common practice to equip them with an insulated wire fastened to the pipe metal and extending aboveground for easy contact.

A second general case is found where sections of an operating line are electrically insulated from the remainder of the pipe by means of insulating flanges. In this case the coated section may range from a few feet to several miles in length.

A third general case is found where a coated pipe line has been laid with Dresser-type couplings. In this case each joint of pipe is largely insulated from the next by virtue of the coupling gasket design. In such case the resistance of the coating on each joint may be determined as for a single isolated buried section.

Fig. 3 illustrates the principles of current flow and voltage change experienced by such buried coated pipe. In each case where a reference electrode is positioned above the coated pipe and the pipe-soil potential measured, the voltage change caused by the current is the sum of the IR drop through both the coating and the soil, or:

$$\triangle E = \frac{IR_s}{X} + \frac{IK}{X}$$

Where:

$\triangle E$ = pipe-soil potential change caused by
I, the total current in amperes,
K, the coating resistance, ohms per lineal foot,
X, the feet of pipe,
R_s, the resistance of the soil annular ring between the reference electrode and the coating per foot of length.

To obtain precise values of K, the IR_s drop must be subtracted from the total. Where radial flow of current is obtained to the pipe the annular soil drop between the reference electrode and the pipe becomes:

$$R_s = \frac{\rho}{2\pi} \ln \frac{r_2}{r_1} \quad . \quad . \quad (4)$$

Where:

ρ = soil resistivity in ohm-feet,
r_1 & r_2 = radius of pipe and radius from pipe center to electrode, feet
$\pi = 3.1416$
ln = natural log.

The coating resistance then becomes:

$$K = \left(\triangle E - \frac{I\rho}{2\pi X} \ln \frac{r_2}{r_1} \right) \frac{X}{I}$$

. . . . . (5)

Where the soil resistance is low compared with the coating resistance the soil drop may be disregarded and:

$$K = \frac{\triangle EX}{I} \quad . \quad . \quad (1\text{-A})$$

Where the coated sample is of small size the procedure is to flow current from a dry cell through a milliammeter through the earth, through the coating to the pipe, and return to the battery. In such case the battery voltage is considered the voltage drop through the coating, and it is not necessary to measure the pipe-soil potential change with the current off and on. The resistance of the coating is usually measured in ohms/sq ft, or:

$$C = \frac{\triangle EAX}{I} \quad . \quad . \quad . \quad (1)$$

Where the coated specimen is of commercial pipe size and of appreciable length, current is caused to flow in a similar manner, either from a battery, or if available, an electrical protection scheme. In either case the voltage of the pipe to the soil is measured both with the current on and off, and the change in potential, $\triangle E$, calculated. Enough voltage points must be taken along the pipe to obtain an accurate average voltage change. For short sections of 20 to 50 ft usually two measurements will suffice. For longer lengths sufficient exploratory points from the drain point must be taken to insure a true average.

The data so obtained are then substituted in formula 5 or 1-A, and the value of K calculated.

Pearson Method

The Pearson Method[6] is adapted for making spot measurements of the resistivity of coatings on operating pipe lines. The area of coating that is integrated into the calculated resistance is not shown by the physical relations involved in the theory but is probably of the order of 10 to 15 lineal feet of pipe.

In this method one copper sulfate electrode, one contact bar, and the potentiometer or other potential metering device, are required for measuring the effect of the impressed current. A power source, ammeter, ground bed, and pipe probe bar are necessary for impressing the current. Equipment is necessary for measuring the soil resistivity. Current can either be obtained from an electrical protection system if one is in operation, or a current source may be supplied by a dry cell connected between the pipe and a steel bar anode set at 30 to 40 pipe depths to one side and at right angles to the pipe. In any case, the current supplied must be sufficiently great that a measurable change in pipe-soil potential is obtained when the current is turned on.

Fig. 4 shows the three positions of the reference electrode required for taking the necessary data. The procedure is to measure the pipe-to-soil potential with the anode current off and then with it on. These measurements are made with the reference electrode first directly over the pipe and then at a right angle distance each side of the pipe equal to three times the depth of burial to the pipe center. A measure is then made of the soil resistivity at sufficient areas around the pipe and within the reference electrode area to obtain an average soil resistance. Substitution of the values into the following formula give the resistance of the coating in ohms per lineal foot:

$$K = 0.367 \left(\frac{\rho 2R_1}{R_2 + R_3 - 2R_1} - \log_{10} \frac{h}{d} \right) \quad . \quad (6)$$

Where:

K = coating resistivity, ohms per lineal foot
ρ = soil resistivity, ohm-feet
h = pipe center depth, feet
d = pipe diameter, feet

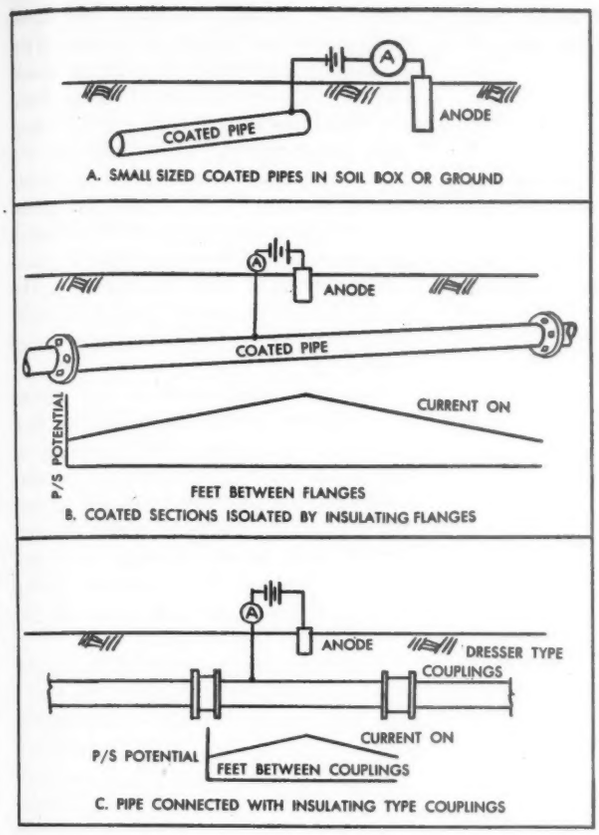


FIG. 3. Typical instances of isolated areas.

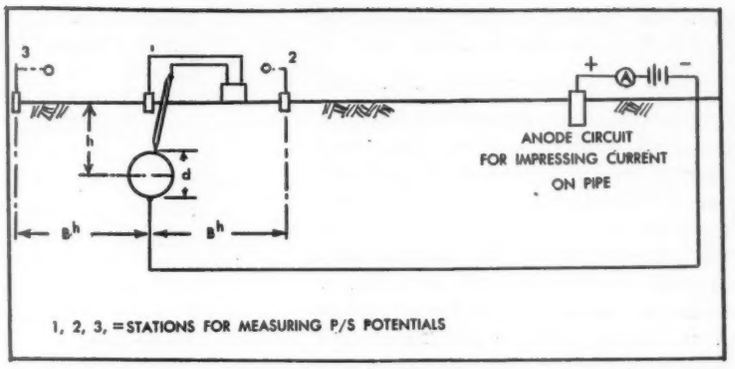


FIG. 4. Test stations required in use of Pearson's method.

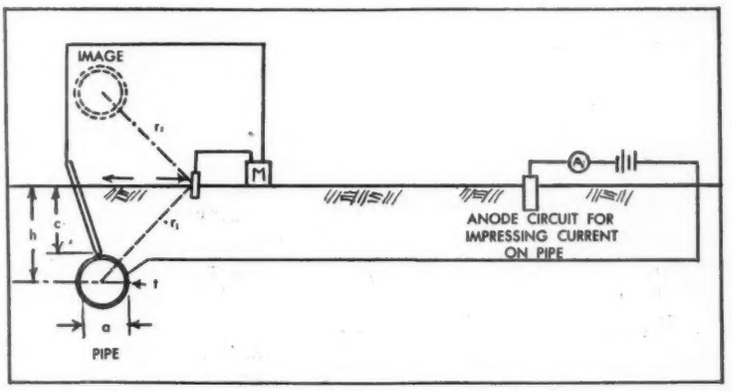


FIG. 5. Scott method for measuring coating resistance.

R_1 = apparent resistance between reference electrode and pipe at location 1 = $\frac{\triangle E_1}{I}$ where $\triangle E_1$ = difference in P/S potential with current on and off and I = total current flow in amperes from anode.

R_2 = apparent resistance at location 2.

R_3 = apparent resistance at location 3.

Pearson states that bare pipes are sometimes found to give a negative value of K and this is due to the accumulation of corrosive products on the pipe surface. In such cases the value of K should be set equal to zero and the resulting value of d found. The value in inches is known as the electrical radius.

In practice it is found that a ½-in. diam steel bar pushed into the ground about 2 ft can be used for an anode. A 45-volt battery impressed between the pipe and anode will give current of 0.10 to 0.20 amp. Even with poor coatings a sufficient value of $\triangle E$ results to enable a value of K to be calculated. The advantage of this method lies in the small amount of equipment needed to make the tests and the fact that after the pipe line is located a set of measurements can be made in 15 to 30 min.

The measurements required and a typical set of data obtained on a wrapped coal tar enamel are:

d = 8 in. = 0.66 ft
h = 30 in. 3h = 7.5 ft
I = 0.200 amp.
ρ = 1254 ohms-ft.

	Location 1 at pipe	Location 2 No. of pipe	Location 3 So. of pipe
E—with I	1.35	1.74	1.37
E—no I	1.14	1.21	1.23
$\triangle E$	.21	.53	.14
R	1.05	2.65	0.70

K = 572 ohms per lineal ft

TABLE 1. Almeda-Lynchburg 8-in. Line

		Coal tar enamel spirally wrapped with 15-lb asbestos felt		
		Pearson Method	Girdle Method	Current-Volt Method
M. P.	ρ Ohm-ft	K Ohms/lin. ft	K Ohms/lin. ft	K Ohms/lin. ft
19.25	19.1	203–415	3163	945
22.00	49.0	77–173	2189	—
25.40	58.5	233	1145	2280
		Goose Creek-Lynchburg 6 in. Coating as above		
—	55.8	294	—	1062

The author has tried the Pearson method on coal tar type enamel coatings on several pipe lines. The value of coating resistance so obtained was compared with measurements made at the same place using either the girdle method or the current-voltage change method described later. In every case the Pearson method gave values that were much lower than obtained by the other methods, as shown in Table 1.

Scott Method

Scott[7] has developed a method for making spot resistance measurements along a pipe line. The method calls for a current output system similar to that required for Pearson's method, except that the anode current need not be known but must be only sufficiently strong to produce a measurable voltage change across the coating. For measuring the results of the impressed current one probe bar, a potential measuring device, tape measure, and two reference electrodes are required. A diagram of a buried coated pipe and its image is shown in Fig. 5. If a potential measure is made between the pipe and a reference electrode stationed at X with the current first flowing and then with it off, a potential drop, E_{ar}, will be obtained that will be the potential difference from the pipe surface through the coating and

from the coating surface through the soil to the reference electrode, or:

$$\triangle E_{ar} - \triangle E_{at} = \triangle E_{tr} \quad . \quad . \quad (7)$$

Scott then calculates from the pipe cover and radius the distance required between two reference electrodes with one stationed at $X = 0$, directly over the pipe, and the other at $X>0$ along the ground surface for the potential drop to be equal to that of $\triangle E_{tr}$, or from the coating face to the ground at $X = 0$. This value along the ground surface is given by the expression:

$$X = \frac{ac + c^2}{\sqrt{a\,(a + 2c)}} \quad . \quad . \quad . \quad (8)$$

Where:

X = distance in feet between the two electrodes at right angles to the pipe and with one at X = 0

a = pipe diameter, feet

c = pipe cover, feet

By subtracting the value of soil annular change in potential $\triangle E_{tr}$ so obtained, the potential drop through the coating alone, $\triangle E_{at}$, is obtained.

$$\triangle E_{at} = \triangle E_{ar} - \triangle E_{tr} \quad . \quad (7\text{-A})$$

It is next necessary to determine the value of current passing through the coating, which results in the potential drop, $\triangle E_{at}$. This is done by measuring the potential between the reference electrode and the pipe at different positions of the electrode along the surface of the ground from $X = 0$ to some final value of $X>0$ caused by the current flow.

If the values of $\triangle E_X$, the potential difference between pipe and soil with the current off and on, are plotted against the expression, $(X^2 + h^2)$ for the various values of X, a straight line will result, the slope of which is $\frac{i\rho}{2\pi}$.

The value of i, amperes per lineal foot, is derived from:

$$i = \frac{(6.28)\,(\text{slope of curve})}{\rho} \quad . \quad (9)$$

The coating resistance, ohms per lineal foot, then is:

$$K = \frac{\triangle E_{at}}{i} \quad . \quad . \quad . \quad . \quad . \quad (1\text{-B})$$

This method is somewhat more difficult to use than Pearson's, largely because of the greater number of calculations involved in taking measurements at the proper place along the earth's surface and calculating the value of i.

The measurements required at each spot are:

1. ρ = soil resistance, ohm-ft
   h = depth of pipe center, ft
   a = pipe diameter, ft
2. With the reference electrodes at varying positions to enable calculation of i, measure with anode current flowing and off,
   E_X at $X = 0 = E_{ar}$
   $X = 1$ ft
   $X = 2$ ft
   $X = 3$ ft
3. Two reference electrodes on ground surface for potential drop corresponding to soil annular ring around pipe. Place one reference electrode at $X = 0$; place second reference electrode at

$$X = \frac{ac + c^2}{\sqrt{a\,(a + 2_c)}}$$

   $\triangle E$ between two reference electrode positions = $\triangle E_{tr}$
4. Calculate K from:

$$K = \left(\frac{\triangle E_{ar} - \triangle E_{rt}}{i}\right)$$

Because of the labor involved as compared with other coating resistance measuring methods, the author has not used Scott's method in comparison with others. The Scott and Pearson methods have a disadvantage in that they are not always applicable where multiple lines are in the same right-of-way. This follows from the shielding effect of the lines and the fact that this results in non-radial current flow to the pipe and the lack of sufficient room to go 3h distance either side for Pearson's method, and 3 ft on either side for determination of i for Scott's method.

Attenuation Method

The attenuation or long line method of measuring coating resistivities is reserved for coatings that have relatively high resistance values and few discontinuities. Results of such a survey lead to average values of K applicable to large sections of the line. The method can be used to cover several miles of coated pipe per day, rather than spot checking the resistance at selected points. The use of this method has been discussed by Rogers,[8] Scott,[9] and others. The general use of the physical relations involved are also used for designing electrical protection systems and have been discussed by Doremus,[10] Pope,[11] and others.

The technique requires a power source for providing test current to the line and equipment for measuring the P/S potential, or current flow on the line, with and without current being dissipated from the anode. The power required depends upon the resistance of the coating. The higher the resistance the smaller the amount of anode current necessary to give a measurable change in potential across the coating at the desired distance from the sending station. For most coatings of the wrapped enamel type, if the measurements are to be made over a distance of several miles from the anode, a current of 1 to 20 amp will be required. This may be too large a requirement for a portable power source. If so, it will be necessary to use an existing rectifier installation or a welding machine in connection with a dug ground bed. The ground bed is usually buried from 50 to 100 ft away from the pipe being tested.

The procedure requires that a man be stationed at the rectifier, welding machine, or other power source, to interrupt the current flow at regular intervals, usually two minutes, to permit the survey party to make the necessary field measurements with and without current flow, without having to wait too long at each point for the current flow to change.

The measuring equipment for the pipe/soil potential requires one probe bar, one reference electrode, potential measuring meter, and connecting leads. The soil resistance is not usually measured. The measuring equipment for current flow on the pipe requires two probe bars, a 100-ft cable, and a potential measuring meter.

Fig. 6 shows a section of pipe and its applied coating. The theory is based upon the fact that the potential drop through the soil and the coating largely occurs through the coating. Under such a condition the potential drop along the pipe caused by a flow of current, I, and that through the coating caused by a differential entry of current, dI, are expressed by the differential equations:

$$\frac{dE}{dX} = -\,AI \text{ along the pipe} \quad (10\text{-A})$$

$$\frac{dI}{dX} = -\,\frac{E}{K} \text{ through the coating} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10\text{-B})$$

One set of solutions of these equations with respect to either the current flow or voltage drop along the pipe are:

$$I = I_o e^{-\alpha X} \quad . \quad . \quad . \quad . \quad . \quad (11\text{-A})$$

$$E = E_o e^{-\alpha X} \quad . \quad . \quad . \quad . \quad . \quad (11\text{-B})$$

Where:

I = amperes current in the pipe at any point, X, measured from the drain

I_o = current arriving at the drain where X = 0

X = feet from drain

$\alpha = \sqrt{A/K}$

A = pipe resistance in ohms per lineal foot

K = coating resistance in ohms per lineal foot

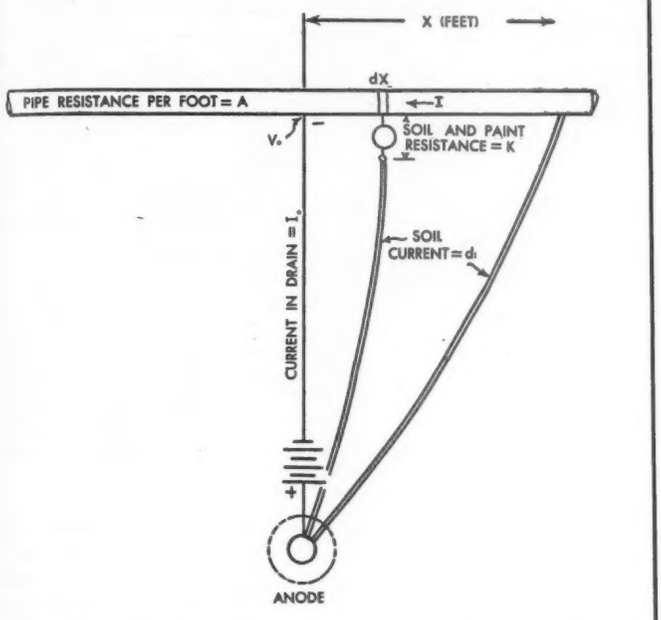
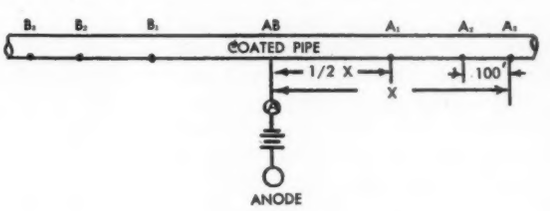


FIG. 6. Relations involved in attenuation method.



Plan View of
Location of Measurements Data:

Calculate current at A_3 and B_3 from potential drop on pipe A_2-A_3 and B_2-B_3. Record current at AB. Measure change in P/S potential at AB, A_1, A_3, B_1, and B_3 and average.

$$K = \frac{2\ Av_1\ \Delta EX}{I_{AB} - I_{A_3} - I_{B_3}}$$

FIG. 8. Current-voltage change method.

As it is common practice to measure P/S voltage changes along the pipe rather than current changes, the treatment will be discussed in that light.

Using relation 11-B, it is desired to obtain field data from which K can be calculated. If the logarithms of relation 11-B are taken the equation becomes:

$$\ln \frac{E}{E_o} = -\alpha X \text{ or } \ln \frac{E_o}{E} = \alpha X \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11\text{-}C)$$

In practice the survey along the pipe consists of measuring the P/S potential at different distances, X_o X_1 X_2 along the pipe with the current off and on. The difference in these values, $\triangle E_o$, $\triangle E_1$, $\triangle E_2$, are used in relation 11-C where the values of $\ln E_o/E$ are plotted against values of X and a straight line results. The slope of this line is, α, and since

$$\alpha = \sqrt{A/k}$$

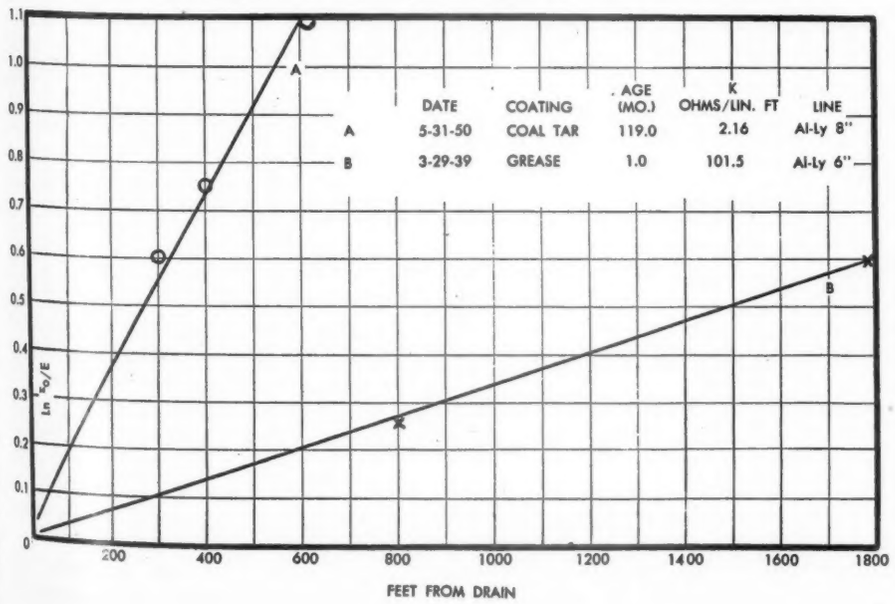
$$K = \frac{A}{\alpha^2} \quad . \quad . \quad . \quad (11\text{-}D)$$

the substitution of values of α^2 in 11-D enables K to be calculated.

Although this method would seem to be a relatively simple one for measuring the resistance of coatings in field use, there seems to be considerable question as to when it is satisfactory. Scott[9] has made use of a form of these relations to study the performance of mastic type asphalt coatings. His paper also includes some data on the resistance of a machine-applied asbestos fabric wrapped asphalt coating. The variations in resistance between coatings ranged from 52,000 to 4,750,000 ohms per lineal foot. In the writer's experience these are extremely high values. It may be that the examination of coatings with resistances in this range may be done competently by this method. Where the coating resistance is below 2500 ohms per lineal foot (for 8⅝-in. OD pipe) it is the writer's experience that values of coating resistance are obtained that are too low. This is particularly true where values of $\triangle E$ are obtained from the drain point to a distance up to approximately 2000 ft, which may be the maximum distance a significant change in $\triangle E$ can be measured.

Fig. 7 shows the data obtained when this method was applied to two lines with poor coatings. The comparison of resistance, calculated by the attenuation method with that obtained in case A by the isolated area method over the same section, and in case B by the current-voltage change method over the same section, are shown in Table 2. It will be noted in both cases that the attenuation method gives results that are much lower than the others, which are believed more significant.

FIG. 7. Measurement of coating resistance by attenuation method.



Current-Voltage Change Method

The Current-Voltage Change Method offers perhaps the most direct and foolproof method available for measuring the resistance of pipe line coatings in place. The method comprises measuring the current in the pipe at two points sufficiently far apart for there to be a current change great enough to be detected by the measuring meter. The average change in P/S potential caused by the current entering the pipe is also measured and the coating and soil resistance is calculated by the relation:

$$K = \frac{\triangle EX}{I} \quad . \quad . \quad (1\text{-A})$$

The method has been discussed by Rogers.[12] It can be used on poor as well as good coatings. It is only necessary that the current on the pipe be measured at sufficiently great intervals for a detectable pickup of current to be associated with a given length of pipe. For poor coatings the current can be measured over a 400-ft section. For a good coating it may be necessary to make the measurements at 5000-ft intervals to detect a significant change. The method can be used on any line of a multiple set in a single right-of-way.

The method and equipment for sending the appropriate current into the pipe is the same as for all other methods discussed. The method used by the writer requires three spotting bars, a 0-10 amp precision ammeter, two 45-volt B batteries, and connecting wire. One spotting bar is driven to the pipe. It is coated to prevent current pickup from the ground. A second bar is placed about 20 ft from the pipe and at right angles. If approximately 1.5 to 2.0 amp can be made to flow with one anode the second is not used, otherwise it is installed. The amperage is read to the nearest 0.01 amp.

The measuring equipment consists of two probe bars, one reference electrode, one potential metering instrument, and a 100-ft cable, which is used in connection with probe bars on the pipe over a 100-ft span for measuring the drop along the pipe. From this potential drop and the pipe resistance obtained by calibration the current flow is calculated. The change in pipe-to-soil potential caused by the current flow is measured at uniform intervals along the line for calculation of the average change, $\triangle E$.

It is to be remembered that the soil IR drop is present in the pipe-soil potential readings taken at each location. These can be calculated out if the soil resistivity is measured. In such case the value of K becomes:

TABLE 2.

Line	Size, in.	Distance surveyed, ft	Coating	Attenuation Method	Isolated Area Method	Current-Voltage Change Method
				K — Ohms/lineal ft		
A	6	2000	Built up grease	101.5	601	—
B	8	600	Coal tar enamel	2.16	—	900

TABLE 3. Almeda-Lynchburg 8-in. Line.

Coated-1940 Surveyed-1946
Coating: Field machine-applied coal tar enamel, spiral wrap 15-lb asbestos felt.
No holiday detection or repairs when laid.

Location	Distance, ft	Average ΔE, volts	I, amps	C, ohms/sq ft
649+75 to 631+32	1843	0.546	0.53	4300
631+32 to 589+93	4139	0.410	2.54	1510
589+93 to 509+27	8066	0.280	0.44	11,600
509+27 to 457+77	5150	0.153	0.37	4840
457+77 to 444+57	1320	0.158	0.12	4000
444+57 to 369+45	7512	0.095	1.294	125
369+45 to 338+31	3114	0.125	0.0369	22,500

$$K = \left(\triangle E_{av} - \frac{I\rho}{2\pi X} \ln \frac{r_2}{r_1}\right) \frac{X}{I} \quad (5)$$

I = current picked up by pipe length, X, in amp. The other notation is the same as used previously.

In making the tests the current as measured by the ammeter in the anode circuit is the total picked up by the pipe. The current in the pipe caused by the anode flow is then measured on each side of the drain and a sufficient distance away for a significant change to be measured. The current in the pipe at the extremities of the measurement is the current outside of the test area. The total current drained, minus the total current outside of the test area, gives the current picked up by the test area.

It is necessary that the total anode current be accurately known at the time the line drop measurements are made in order to calculate the actual current pickup by the coating. It is also necessary to calibrate the pipe resistance because the commonly used tabular values may be incorrect.

Fig. 8 illustrates one set of arrangements used in making the tests. Other arrangements of test location with respect to the drain may be used if desired. The method has been used to examine the resistance of several coated lines. A comparison between it and the attenuation method for a low resistance coating is given in Table 2. A comparison with the Pearson and Pattern-Resistance methods is given in Table 1. Table 3 gives the results on a line surveyed in 1946.

Distributed Anode Methods

A. Sacrificial anodes. There are in operation many installations of sacrificial anodes of the magnesium or zinc types protecting sections of coated pipes. It is possible to use data obtained from such installations, if their current output can be measured, to calculate the resistance value of the coating. Such calculations are approximate but they serve to indicate the order of resistivity of the coating and can be used to follow the change with time.

Fig. 9 shows the usual arrangement of placing sacrificial anodes along a pipe line. The spacing approximates 50 to 250 ft. The figure also shows the normal distribution of the pipe-soil potential along the coated pipe from anode to anode. The current output of such anodes is usually easily measured. In many cases a resistance of known value is placed in the circuit and a potential drop measurement across it enables the current to be calculated.

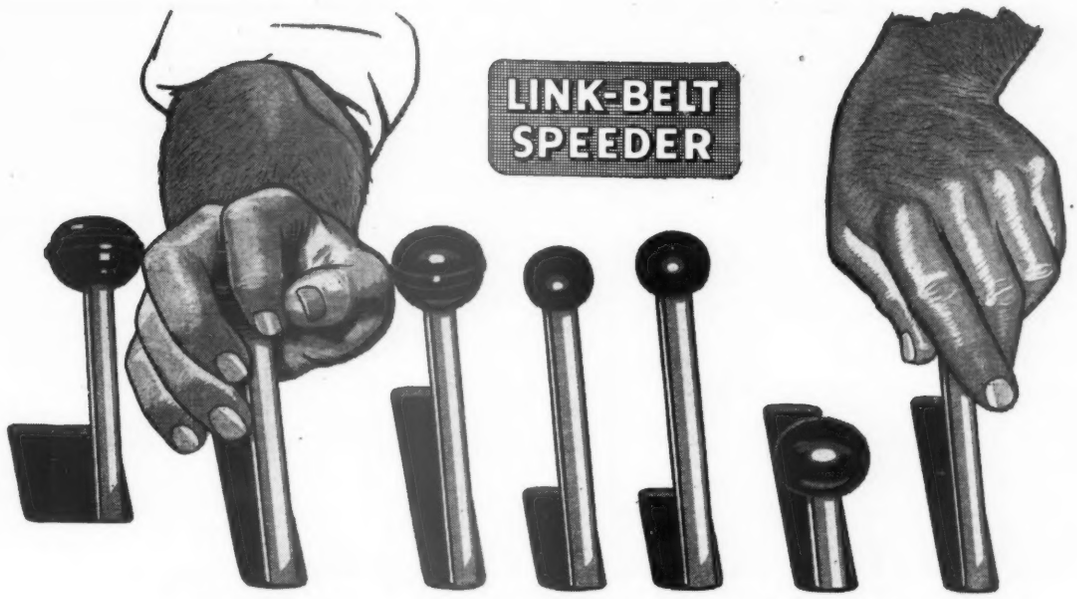
The equipment necessary for such a survey includes a reference electrode, potential measuring meter, and probe bar. A fixed known resistor for insertion in the anode return wire or an ammeter for measuring the anode current is required.

In practice the potential of the pipe to the soil is measured opposite the anode and along the pipe halfway to the next anode, with the anode current flowing and with it off. The average change in potential, $\triangle E_{av}$, then is considered as being caused by the current flow of the anode supplying current to that particular area. The value of K is then calculated:

$$K = \frac{\triangle E_{av} X}{I} \quad . \quad . \quad (1\text{-A})$$

This value of K includes the soil IR drop, which tends to increase the apparent resistivity of the coating. If it is desired to calculate the IR drop out it is necessary to measure the soil resistivity and the distance between the outer surface and the soil contact end of the reference electrode. Equation (5) is then used.

A typical set of measurements made along a distributed anode system is



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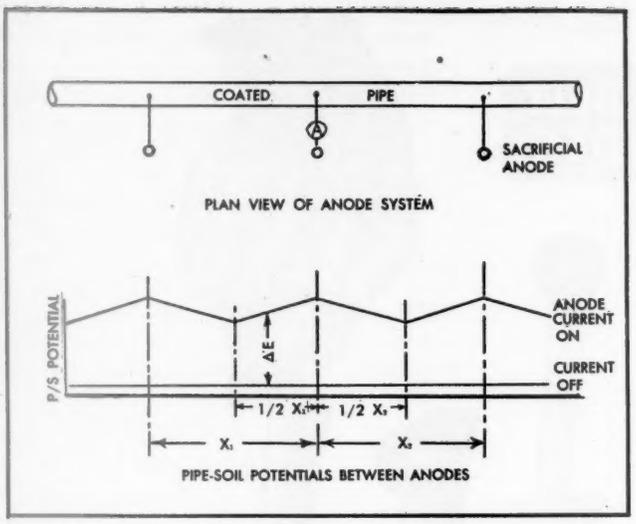
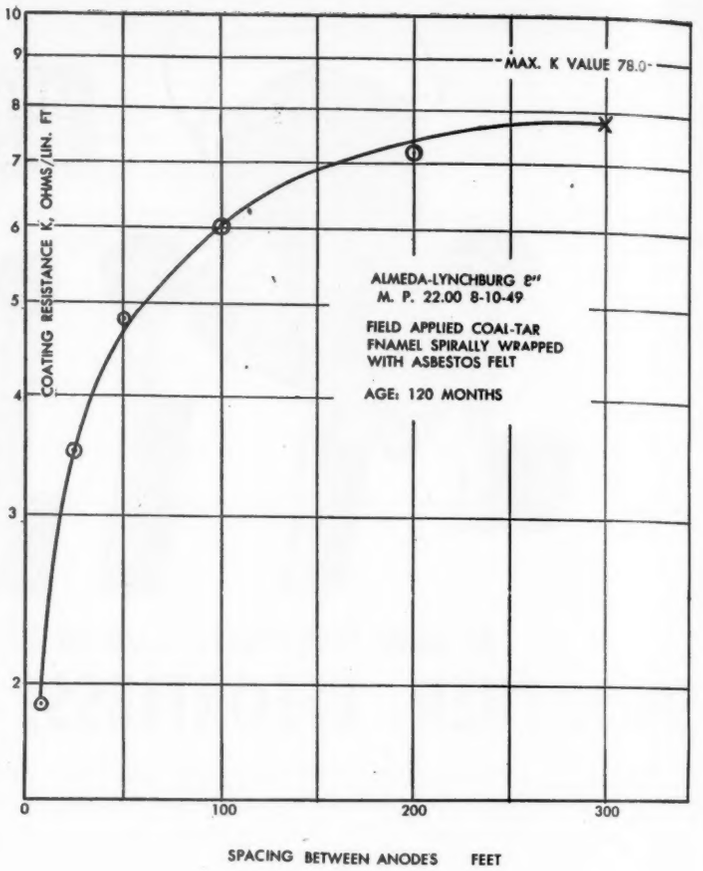


FIG. 9. Sacrificial anode method.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FIELD APPLIED COAL-TAR ENAMEL SPIRALLY WRAPPED WITH ASBESTOS FELT
AGE: 120 MONTHS
SPACING BETWEEN ANODES FEET

FIG. 10. Use of variable position test anodes to measure coating resistance.

given in Table 4. This was a yard wrapped coating of coal tar enamel, spirally wrapped with asbestos felt. The coating had been in service 13 months when the measurements were taken. The low values are thought to result from the severe handling the coating received when laid and the fact that none of the holidays so received were repaired.

B. Variable position test anodes. Inasmuch as the use of distributed anodes makes a simple method of measuring the resistance of a coating, tests were made to determine the accuracy of such a method for regularly surveying the resistance of coatings in place. The method consisted of installing three anodes along a coated pipe line. The anodes were single ¾-in. steel bars driven into the ground from 10 to 15 ft from the pipe and at right angles to it. A battery was used at each anode to supply 0.100 to 0.200 amp current to the pipe. The current was measured with a milliammeter.

TABLE 4. Lynchburg-Goose Creek 8-in. Line

Coal tar enamel wrapped with 15-lb asbestos felt. Coating yard machine applied, not inspected or repaired when laid.
Laid: June, 1947 Inspected: July, 1948

Anode Number	Effective distance, ft	P/S. Potential volts	Current amp.	K, ohms/lin.ft
10	75	0.275	0.342	60.5
11	145	0.259	0.268	135
12	195	0.250	0.167	293
13	305	0.190	0.360	161
14	355	0.220	0.180	435
15	350	0.130	0.029	1570
16	250	0.130	0.027	1205
17	100	0.160	0.042	385
18	100	0.180	0.235	76.5
19	100	0.190	0.190	100
20	100	0.160	0.165	97.5

The purpose of using three anodes was for the outer two to force the current from the center anode to reach the pipe within the distance between anodes. Thus, knowing the current output of each anode and having the currents all equal the resistance of the coating would be calculated by the equation:

$$K = \frac{E_{av} X}{I} \quad . \quad . \quad (1\text{-A})$$

Where:

I = center anode output, amperes
X = spacing between anodes, feet
E_{av} = average change in pipe-soil potential of the coated pipe, a distance ½ × each side of the center anode with the current off and on.

Using this method, a test was made to determine K at different values of anode spacing. These were varied from 10 to 200 ft. The data are shown in Fig. 10. The curve shows that the apparent resistance of the coating increased with the spacing between anodes. The value of K reached a maximum of 78 ohms per lineal foot with a 300-ft spacing between anodes. The values of K obtained along the same area, using the Current-Voltage Change and Pattern Resistance methods, varied from 1000 to 2000 ohms per lineal foot.

The reason for the failure of the distributed anode method to properly evaluate K is that at short anode spacings the current from the center anode is not restricted to the total between it and the outer two anodes. Thus, not knowing the true value of current to assign to the values of pipe-soil potential measured, it is not possible to calculate the coating resistance.

Doremus[10] has shown a relation for calculating the effect of adding additional equi-spaced anodes along a line on the pipe-to-soil voltage. Basically the greater the number of anodes the greater amount the current from the inside anodes will be restricted to the immediate area. The relation for a set of anodes is:

$$E = 2E_o\,(e^{-\alpha X} + e^{-3\alpha X} + e^{-5\alpha X} + e^{-(n-1)\,\alpha X}$$

Where:

$\alpha = \sqrt{A/K}$
X = ½ distance between anodes, feet.
E_o = pipe-soil potential at an anode due to its influence alone.
E = pipe-soil potential at the center distance (X) between the innermost two anodes.
$E = 2E_o\,e^{-\alpha X}$ is the pipe-soil potential at the center point due to two adjacent anodes.
$E = 2E_o(e^{-\alpha X} + e^{-3\alpha X})$ is the potential due to the four adjacent anodes, etc., to $e^{-(n-1)\,\alpha X}$

The change in E as the total number of anodes is increased from two

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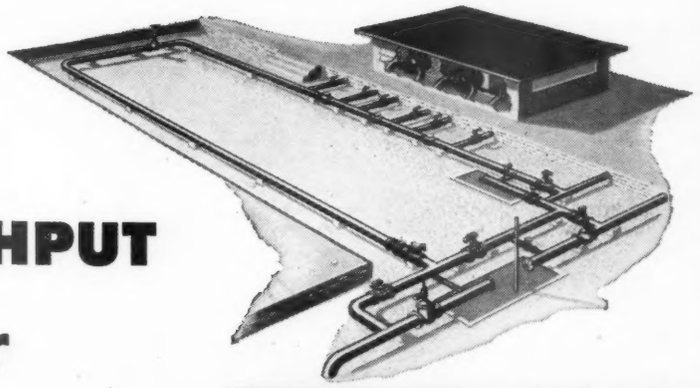

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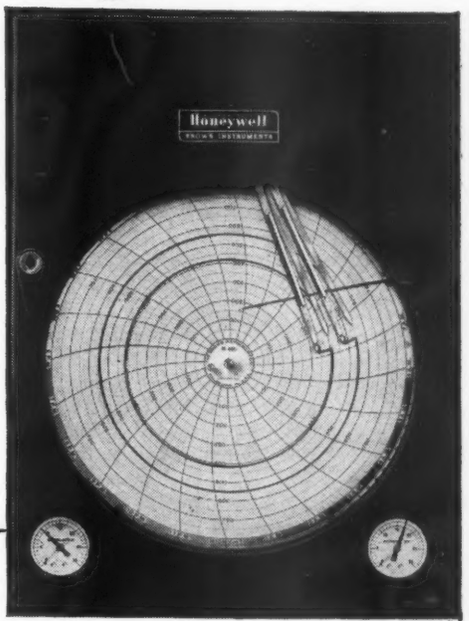
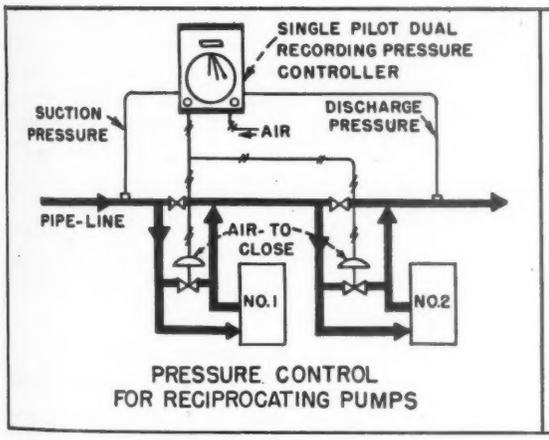
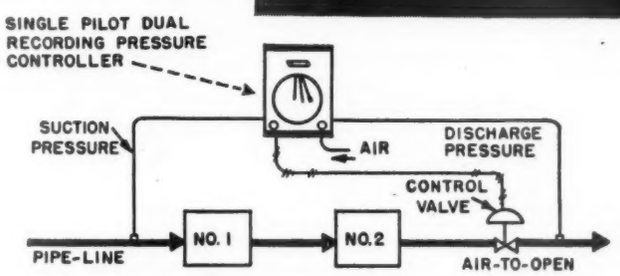




PRESSURE CONTROL FOR RECIPROCATING PUMPS



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to eight for a 2000-ft spacing is shown by a calculation for a poorly coated 8-in. pipe:

$A = 7.6 \times 10^{-6}$ ohms per ft

K = 100 ohms per lineal ft (assumed value)

$\alpha = 2.8 \times 10^{-4}$

Let:

$E_o = 0.100$ volt

X be 1000 ft

Now:

E with 2 anodes = 0.1512 volt

E with 4 anodes = 0.2366 volt

E with 6 anodes = 0.2846 volt

E with 8 anodes = 0.3116 volt

Thus, as the number of anodes in the system increases so does the center pipe-soil voltage because of the increased current received by the pipe from the center anodes.

This relation illustrates the effect of increasing the number of anodes on the pipe-soil potential and shows that where coating resistance values are calculated by the sacrificial anode method the more anodes in the system the more nearly true value of K can be obtained.

Summary and Conclusions

A study has been made of seven methods for measuring the electrical resistance of pipe line coatings. The Current-Voltage Change method is considered the most practical for use. Where a coating has a high resistance the data obtained on a current-voltage change survey can be used to calculate the K value for the coating, using the relations of the attenuation method. Where coatings can be applied to areas that are electrically insulated from other portions of the line the isolated area test makes a suitable method.

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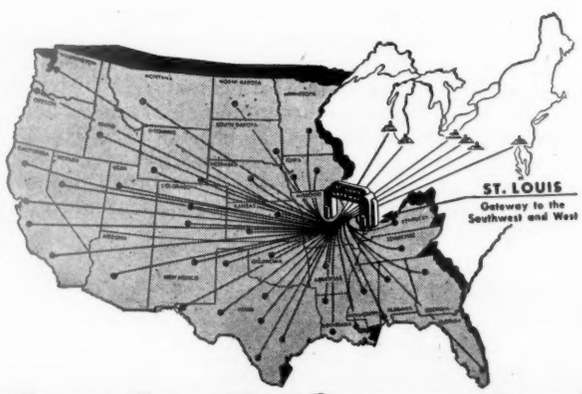

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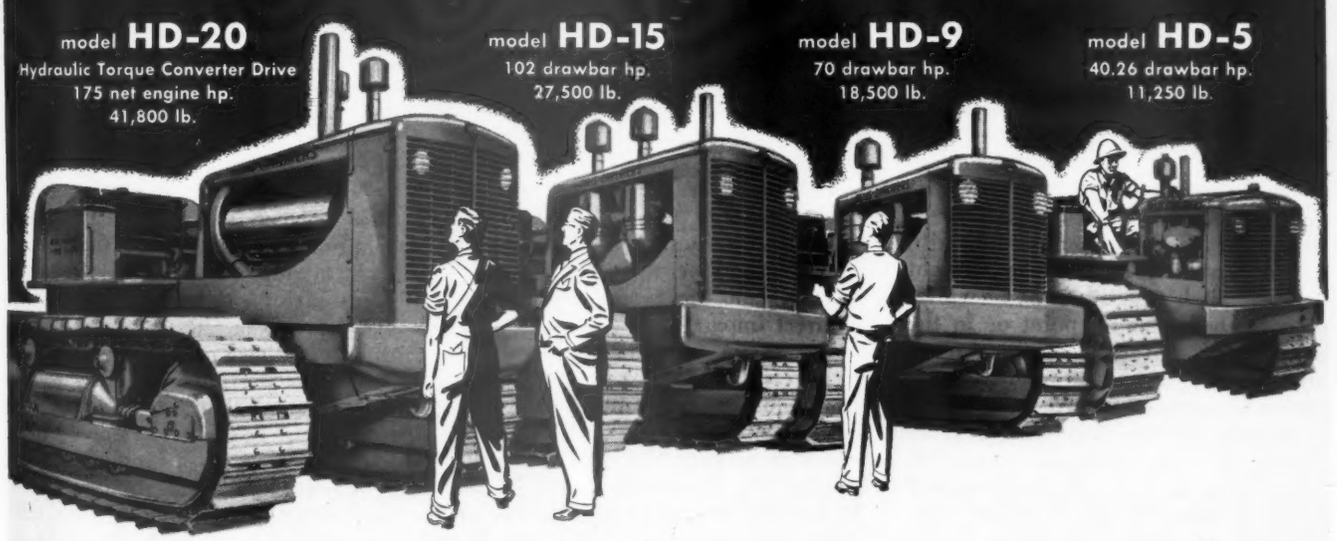

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Part 2—Conclusion

Significance of Tests

What is the significance of the laboratory tests?

It is necessary to consider the narrow range enamels separate from the moderate and wide ranges.

Only five tests need be considered in conjunction with the narrow range enamel. They are: Softening point, ash, stripping, sag, and cold tests. Softening point and ash give the balance between the pitch and the filler, assuming that the maufacturer is using a low loss on ignition filler. The softening point tells the approximate application temperatures and whether or not the coating is suitable for the application at hand. Stripping tests show the quality of the primer. Sag and cold test tell whether the coating is within the limits specified. Other tests have little meaning because the legitimate manufacturer is using straight coal tar pitch and, other than a variation in the softening point or in the amount of and type of filler used, there is little he can do to change the characteristics of the coating.

Specific gravity does have a great deal of bearing from the standpoint of coverage and for adulteration, but from the physical aspects of the coating does not control the action of the coating as much as the other points discussed above.

The important points in testing the moderate and wide range enamels are: Softening point, ash, penetration, stripping, sag, and cold test. Again softening point gives an indication of the application temperature of the coating and the softening point combined with the ash gives the balance between the two. On wide range coatings, the softening point also gives some indication of the sag point of the coating, for in most cases the sag point is 60 to 70°F below the softening point. This point is also controlled by the penetration, however. If the penetration is off, the softening point might be 250 F and the coating might still only have a sag point of 140 F.

The deciding factors are the softening point and the relationship between the penetrations at 77 F and 115 F. In other words, if the softening point is 220 F, the penetration at 77 F is 10 and at 115 F is not above 24, the coating will pass all other tests provided that the primer passes the stripping test. If the softening point was 220 F, however, the penetration at 77 F was 10 but the penetration at 115 F was 35, then the coating probably would not pass either the sag test or the cold test. The significance of the penetration is this: If the ratio of the two penetrations is 1:2, or approximately that, the softness of the coating does not increase rapidly with increase in temperature, or going on the cold side, it does not harden rapidly with lowering of the temperature. If the ratio is 1:3 to 1:5 then the coating is changing rapidly with slight changes in temperature.

All this means that if the softening point, ash, and penetration are in balance, and assuming a good primer, then the coating will pass such tests as sag, cold, cold bend, direct, and indirect impact.

A test not normally included is a test of softening point, and penetration before and after heating at application temperature; that is, samples taken as soon as the coating reaches application temperature and after 2 hr holding at application temperature using approximately 3500 grams in a 1-gal can with a plate laid over the top during the heating period. The softening point should not rise more than 4 F, and the penetration at 77 F should not fall more than half the original penetration. Should the softening point decrease, it indicates that the process of manufacture was not complete, and should the softening point increase excessively it indicates one of two things: (1) An unstable product, or (2) the presence of large amounts of light oils. The question of oils may be eliminated by weighing the container of coating just as it reaches application temperature and after the 2-hr heating. Each per cent of oil lost is equivalent to an increase in softening point of approximately 3 F.

What happens in the field and why? A great many things happen in the field that make the applicator, inspectors, and service men jittery. It is difficult to know where to start, but an attempt will be made to answer a few of the problems met in field application of the coatings.

Primer and primer application. Application and drying of primers cause as much trouble as any other factor and it is difficult at times to see just why these troubles occur. Primers are solutions of the desired pitch in coal tar solvent. The solvent is selected for most rapid evaporation with greatest solvency for the pitch. Consequently, the evaporation of the solvent and the application of the primer to metal, followed by the subsequent drying or evaporation of the solvent, governs the time necessary for drying before the enamel may be applied.

Narrow range primer is the simplest because it is more nearly a true solution of the pitch in the solvent. It is manufactured and its viscosity adjusted for summertime use. As the viscosity of the pitch solution changes rapidly with changes in temperature, similar to the pitch itself, it is easy to understand that as outside temperatures drop below a normal 70 to 80 F the viscosity rises rapidly so that a primer that is just right for application at 70 F is far too stiff and thick for application at 35 F. Even though the primer were kept warm, if the metal temperature is 35 F, the instant the primer touches the metal the primer is cooled, and is applied too heavily. By the same token, lower temperatures mean lower vapor pressures of the constituents of the solvent with a consequent slower evaporation. Thus a primer applied at 77 F, that dries in one hour at that temperature, will require 6 to 8 hr at 35 F. Now if the primer is applied heavier because of the lower temperatures, that also increases the drying time. As a result, many of the applications made during winter months are made over primer that is not dry. There is a compensating factor. This point has caused no end of worry because primer applied as above in cold weather will appear dry in from one to three hours when the cold pipe is touched; however, if a warm hand is held against the primer surface until the metal warms a little, the primer

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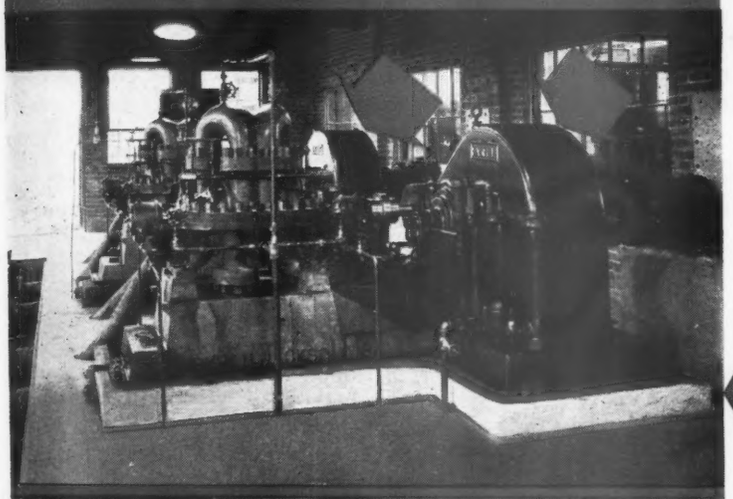

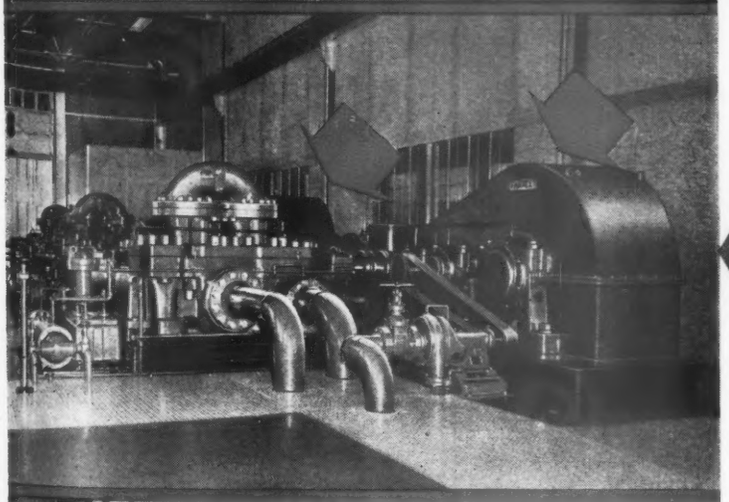

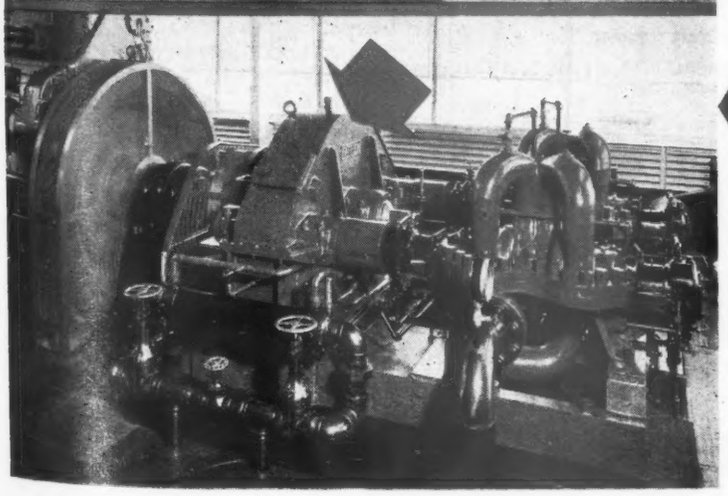

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will show that it is not dry by sticking on the hand when the hand is removed. Then, why is a good bond obtained?

The answer is probably as follows: The narrow range enamel pitch is fairly soluble in the coal tar solvent. When the enamel is applied over the apparently dry, but still wet primer, the metal and primer are warmed by the coating. Immediately after the application, the coating could be stripped, but not after the primer and coating have returned to the original metal temperature. During the warm period and afterward, the remaining solvent distributes itself through the enamel and eventually escapes into the air.

To avoid thick application in cold weather, there is only one course to follow: Thin the primer with thinner. This is done only on recommendation of the manufacturer. He knows his own product and can best judge and recommend adjustment.

There are also troubles in the summer. In extremely warm weather with hot sunshine, metal temperatures may go as high as 140 F, and after application of the primer, presenting a black surface to the sunlight, may reach 160 F or above. Due to these higher temperatures the primer spreads extremely thin, the evaporation of the solvent is fast and the primer may be completely dry in less than 15 min. This primer will bond well if the coating is applied shortly afterward, but if the temperature of the metal remains high and the coating is applied several hours later, the coating may not bond to the primed surface. In such cases the primer loses its gloss and becomes so brittle that it may be brushed from the surface of the metal easily. In some cases it has been found that the primer on the top of the pipe will not bond whereas that on the under surface bonds perfectly. This trouble is caused by evaporation of oils from the pitch due to the high temperature of the metal, with a consequent increase in the softening point of the pitch to such an extent that the coating when applied cannot wet or melt the surface primer in order to make bond. The under surface of the pipe does not get as hot as the top surface, therefore, it does not lose as much oil and gives a good bond. This condition of the primer is normally called "dead primer" in the field.

Thus far, it has not been possible to completely eliminate this difficulty. The applicator can improve the situation in the field by applying the primer in a heavier coating in hot weather. If the delay in applying the coating to the primer has been long, a quick, thin application of primer over those surfaces exposed to the sun before applying the coating will bring back the life to the primer.

It is readily seen that there is no way in which a manufacturer can tell the applicator what the drying time of the primer should be. In cold weather, drying time may be 48 hr, in warm or hot weather 15 min, or in warm humid weather 12 hr. It is up to the applicator to determine whether his primer is dry by watching weather conditions, pipe temperatures, thickness of primer coat, and determine either by feel or by actually pouring a dipper full of enamel over the primed surface and checking the bond. Experienced applicators have learned to do this; in many cases without realizing what is being done.

It is best never to heat the primer before application other than to store it in a warm place. It is better to thin it than to heat it.

Many of the things pointed out for narrow range primer hold true for moderate and wide range primers; however, wide range primer is much more critical and requires more care in handling and drying than narrow range.

This primer is probably a dispersion so that its viscosity change with change in temperature is more nearly like the solvent and is not as great as

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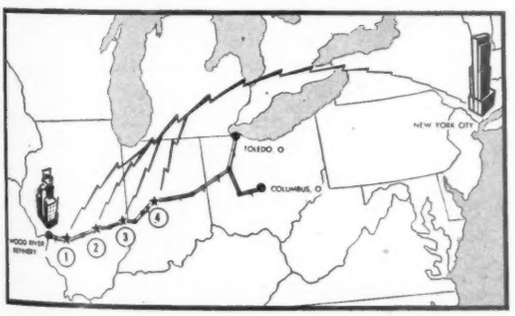

From almost halfway across the country, central dispatcher in New York's Radio City controls flow of 22 different products through 4 new booster stations in Illinois and Indiana. Thanks to the combined efforts of Shell, A.T. & T., and G-E engineers, line capacity is now up by 168,000 gallons a day, with man-hour needs kept to a minimum.

G-E engineering and equipment in 4 new remotely-controlled Shell stations help boost line capacity, cut man-hour costs

A central dispatcher in New York dials some code numbers. Hundreds of miles away — in one of four new booster pumping stations on Shell Oil Co.'s East Products Pipeline—General Electric switchgear, control, and accessory equipment goes into action. In proper sequence, motorized valves are opened and closed, pump motors started and stopped, operating reports sent, or the station's single maintenance attendant summoned for an emergency — all automatically!

G-E engineering and equipment — which played a major part in this first application of long-distance automatic remote control to pipeline stations—can help electrify *your* pipeline as well for higher throughput, lower costs. Your G-E representative will gladly show you how. *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*

Everything you need to cut oil pipeline costs —ELECTRICALLY!

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661-24

for narrow range primer. It does not become as thick at lower temperatures nor as thin at higher temperatures. It does not go "dead" nearly so fast, and in fact the higher pipe temperatures within limits aid the primer. To a certain extent, it dries faster in cold weather, but it is more essential that all solvents be evaporated from the primer before application of the coating to the pipe. Solvent is not absorbed into this type of coating. If the wide range coating is applied over the wet primer, the solvent from the primer collects at the interface beween the primer and the enamel, giving a soft sticky surface, so much so that there is no bond even after months of standing.

TABLE 3. Primer viscosities at various temperatures.

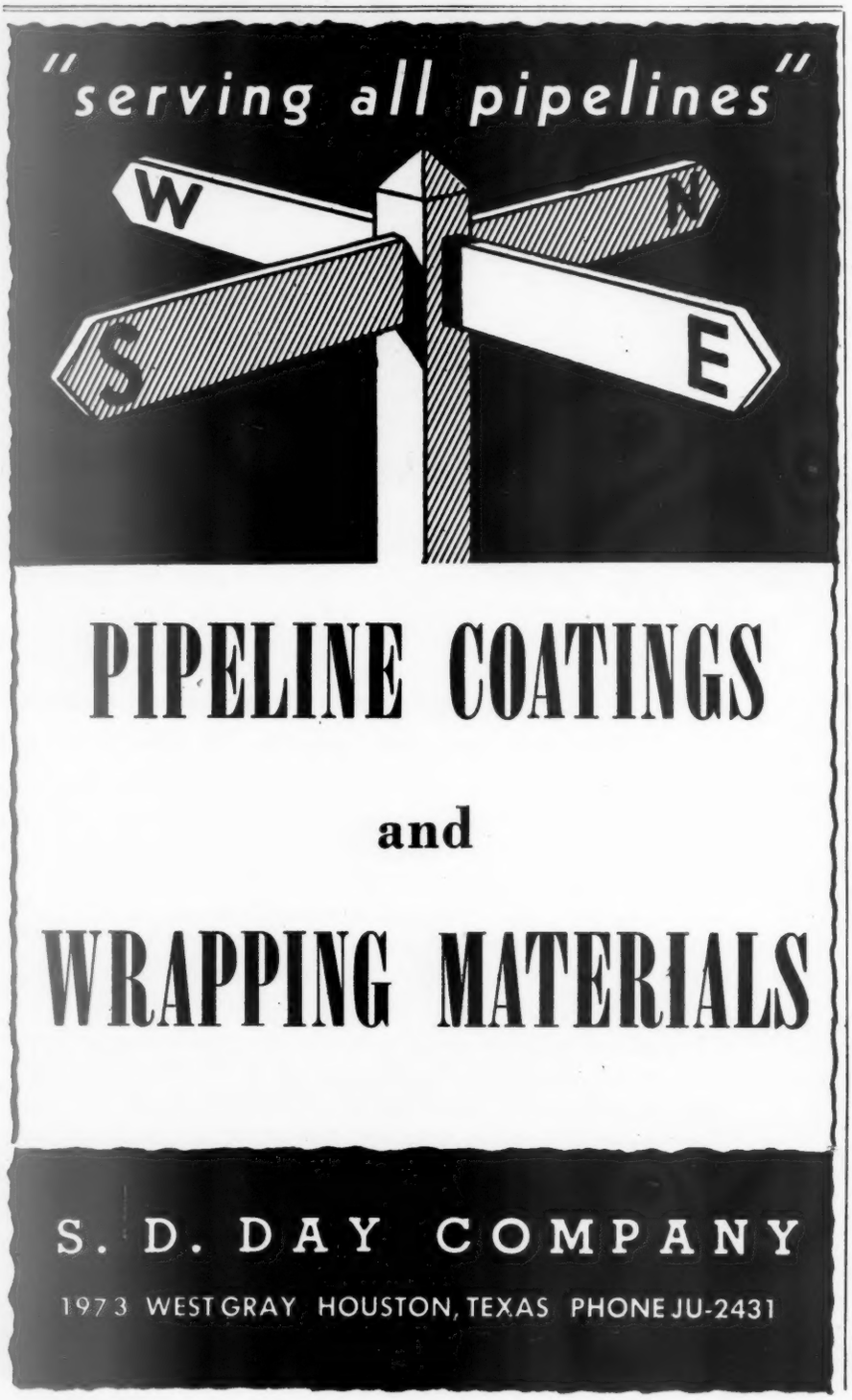
	Viscosity, Stormer, Cylinder Rotor, 100 g., wt.		
	Narrow range primer	Moderate range primer	Wide range primer
	seconds	seconds	seconds
100 F	20	28	40
77 F	58	53	60
60 F	125	88	95
50 F	215	144	125
40 F	580	202	165
30 F	650	269	210

The drying time in this case with different weather conditions and temperatures is just as problematical as for the narrow range primer but in this case dry primer free of solvent is essential. Table 3 gives some indication of the wide differences in the thicknesses or viscosities of the primers with changes in temperature and shows why it is rarely necessary to thin moderate and wide range primers in cold weather.

The reconditioning of old metal often is a serious problem because the metal is pitted and the pits contain rust and dirt. Often in coating such metal the coating will show an excessive number of holidays, probably because of the air and gases entrapped in the pits. This is one case where, in applying narrow range primer, it is better to apply the coating before the primer is completely dry. The heat of the coating seems to flow the primer into the pits and helps to eliminate the gases.

Enamels. Too much stress cannot be placed on the care in handling enamels for application, such as cutting, heating, and holding at application temperature. If the coating is placed in the heating kettles in too large pieces, more heat is required and longer time to melt the material. This may result in coking in the kettles. Heating too hot and too fast at the start before it is possible to agitate the kettles also results in coking. Kettles must be closed at all times, lids must fit tightly. Vapors escaping from the kettle means that the coating is losing oils, the softening point is rising, and the penetration dropping. Agitation is essential. Although the manufacturer selects his filler to have the least possible amount of settling, a kettle held at application temperature over long periods of time without agitation is bound to have settling with consequent coking in the bottom of the kettle. Newer kettles now on the market have greatly reduced these hazards. Do not apply more heat than is necessary to keep the coating at application temperature. Overheating raises the softening point by loss of oils and the coating can no longer do the job it is supposed to do.

Application temperature cannot be given specifically because the thickness of the coating required, metal temperatures on which the coating is being applied, and distance the enamel travels from kettle to pipe, govern the application temperature or the



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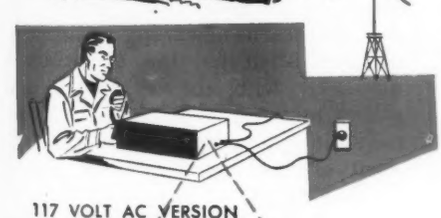

117 VOLT AC VERSION
AS A BASE STATION

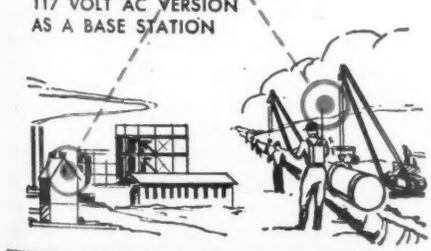

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TABLE 4. Typical approximate application temperatures for the various enamels.

Narrow and moderate range enamels

Metal temperature, F	1/16 in. coating thickness		3/32 in. coating thickness	
	Temp. of flow on metal, F	Kettle temp., F	Temp. of flow on metal, F	Kettle temp., F
Below 50	400	435	390	425
50—60	390	425	380	415
60—80	375	400	365	390
80—100	365	385	355	375
100—120	355	370	340	360

Wide range

Metal temperature, F	1/16 in. coating thickness		3/32 in. coating thickness	
	Temp. of flow on metal, F	Kettle temp. F	Temp. of flow on metal, F	Kettle temp., F
Below 50	460	485	450	475
50—60	455	480	445	470
60—80	450	475	440	465
80—100	440	465	430	455
100—120	430	455	425	450

kettle temperature. The kettle temperature and the temperature at which the coating flows over the metal are different depending upon the time and space of transfer between the kettle and the metal. Table 4 illustrates a general, approximate set of application temperatures taking into consideration, thickness of coating desired and metal temperatures.

One example may serve to illustrate: In Ohio a few years ago, coating was being applied to 6-in. steel pipe. The day was hazy, no sun. Required coating thickness was 3/32 in. Between 7:00 a.m. and 10:00 a.m. the air and metal temperature averaged 45 F. The coating was heated to 425 F in the kettle, and was flowing onto the pipe at 400 F giving a 3/32 in. thickness. Between 11 a.m. and 1 p.m. the temperature rose to 70 F. The kettle temperature was 400 F and flow to pipe was 375 F. From 1 p.m. to 3 p.m. the temperature dropped to 60 F and the kettle temperature was raised to 410 F.

Bonded wrappers. Bonded tar-saturated asbestos felts have been used for a long time on pipe lines and other coated surfaces. The felt is applied at the same time as the enamel so that the coating is not only bonded to the metal but to the felt as well. This bonded wrapper does give protection to the coating, particularly coating underground where it is subjected to soil stress, and pressure by stones and other objects that tend to puncture the coating. Rag and other felt is used.

Some trouble occasionally occurs due to moisture absorption in the felt. If the felt has absorbed moisture, it may cause bubbles in the coating and result in holidays. A simple field test for moisture is to stick a strip of the felt into the coating at application temperature. If the felt pops and fries, it is a good indication of moisture. The felt does not materially affect the cold test on the coating.

Fairly new on the market are a number of glass wrappers composed mainly of a mat of fine glass fibers sufficiently porous so that, when applied over the coating while the coating is fluid, the coating penetrates up through the glass and flows out on top of it. Even though the glass becomes completely covered by the coating, the surface of the coating usually shows the cross fiber structure of the glass. If the glass is followed by a kraft or felt wrapper the surface becomes smooth. This wrapper has come into quite general use. The glass is non-water absorbent and relatively inert. It does strengthen the enamel coating and tests have indicated it lowers the cold test or cold cracking test on the coating. For maximum benefit from this wrapper it must be near the outside surface of the coating, well bonded into it, and must be thoroughly covered by the coating. If not well bonded it offers very little protection to the coating.

Handling coated metal. Everyone is well aware that it is necessary to handle coated metal with care, use wide belt slings, or, if rolling onto skids, use skids with wide bearing surfaces, well padded and plenty of them.

There is an erroneous idea that the cold test of a coating is the temperature at which the coating may be handled. If the metal coated is like steel pipe or objects that will bend or flex when handled, such objects cannot be handled at low temperatures or at temperatures near the cold test temperature. It is very difficult to pick up or handle steel pipe coated with standard enamel at even 50 F metal temperature. Plasticized and modified enamels may be handled at lower temperatures, but extreme care must be taken and any flexing or bending must be done slowly.

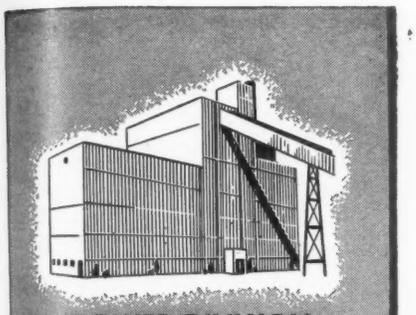
Bending of coated pipe. Frequently it is necessary to bend coated pipe in the field and this may be done without serious injury to the coating. If the coated pipe is too warm, the coating will be too soft and thin down from the pressure; if too cold, it will crack and shatter as the pipe bends. In general, wide range enamel will take bending easily between 70-80 F, moderate range between 75-85 F, and narrow range between 85-100 F. During warm weather there is never much difficulty, however, in cold weather, bending is a problem. Two common methods used to warm up the pipe in cold weather are: (1) A kerosine burner is set in the end of the pipe until the pipe is warm, or (2) in some cases about a pint of kerosine is thrown into the pipe section and ignited. The pipe is rolled while heating to obtain uniform heat.

Flux in coatings. The addition of flux to a coating is never recommended, but sometimes becomes necessary. Fluxing may be necessary when a coating has been held at application temperature too long, oils evaporating from the coating causing an increase in the softening point and a decrease in the penetration. Flux is also used on applications made where the exposure temperature is below the cold test point of the coating. In such cases, the addition of flux is suggested, but only at the recommendation of the coating manufacturer.

There are many things that may come up in the use of the coatings in the field that are questionable. The coating manufacturer is always willing and ready to give information and help out on the difficult jobs. By so doing he learns new things, new methods, and often questions and troubles discussed with the applicator and others in the field result in improvements in the coating and the development of new coatings to serve new needs.

Much credit is due the coating manufacturers for their constant work and progress, with the help of the corrosion engineers of the oil and gas companies, in the development of specifications to suit the needs of oil and gas lines. Specifications have been tightened and narrowed to such an extent that the manufacturer must be extremely careful in the control of products difficult to make.

Credit is also due the corrosion engineers and applicators for their vigilance and help to the manufacturer in keeping him informed of the problems, difficulties, and performance of the coatings in the field, as well as giving praise where praise is due. It has been the excellent cooperation of all these people and the inherent good qualities of the coal tar base that has given these coatings their excellent acceptance today! * * *



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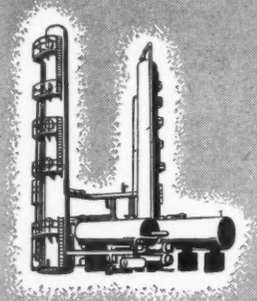

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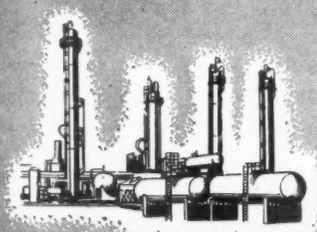

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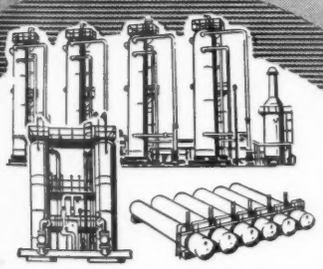

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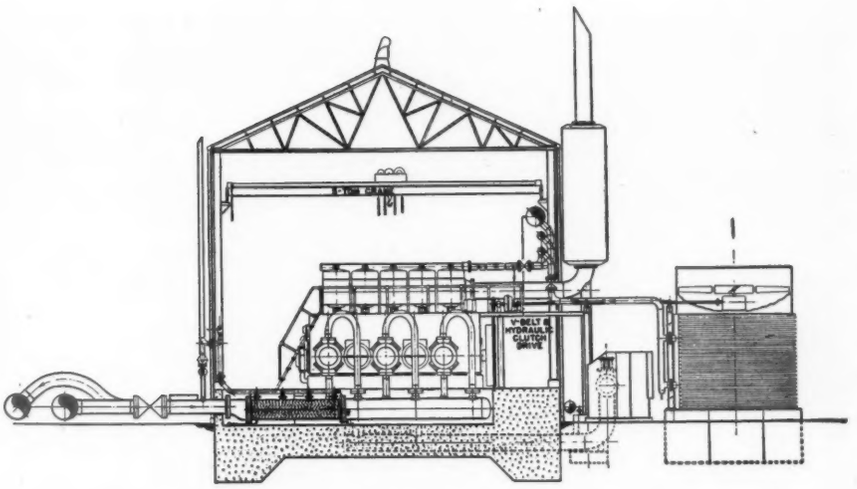

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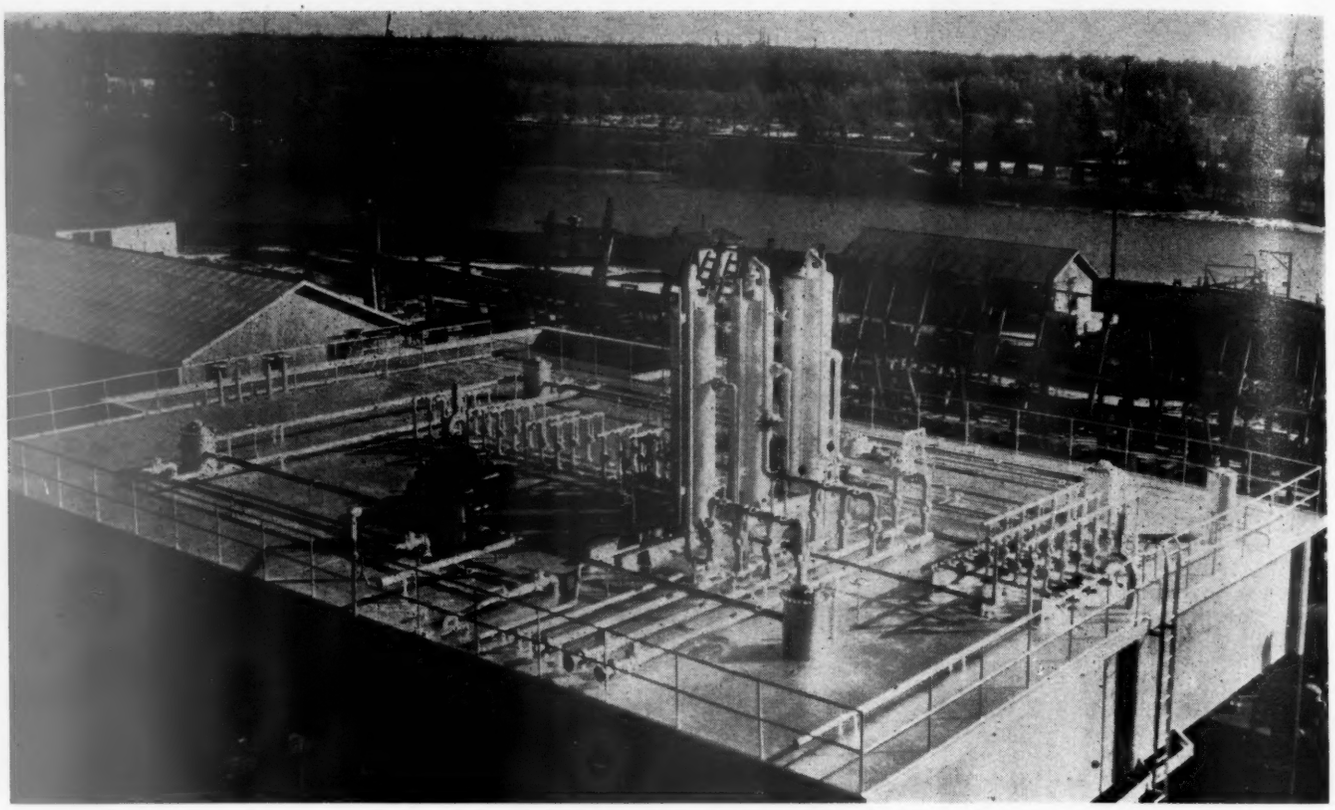


Top deck view of oil storage tank battery barge. Oil and gas handling equipment installed to Gulf Oil Company specifications is shown.

Submersible Tank Battery Barge

A Substitute for Piling-Supported Wooden Platforms Erected To Carry Interim Oil Storage Tanks—the First of Its Kind

THE first submersible oil storage tank battery barge ever built was commissioned December 6, 1950, in the Beaumont yard of Bethlehem Steel Company. Designed and constructed at the yard by Bethlehem in close cooperation with Gulf Refining Company, the barge is now in service in Black Bay, Louisiana. It affords storage capacity for 4800 bbl of crude oil.

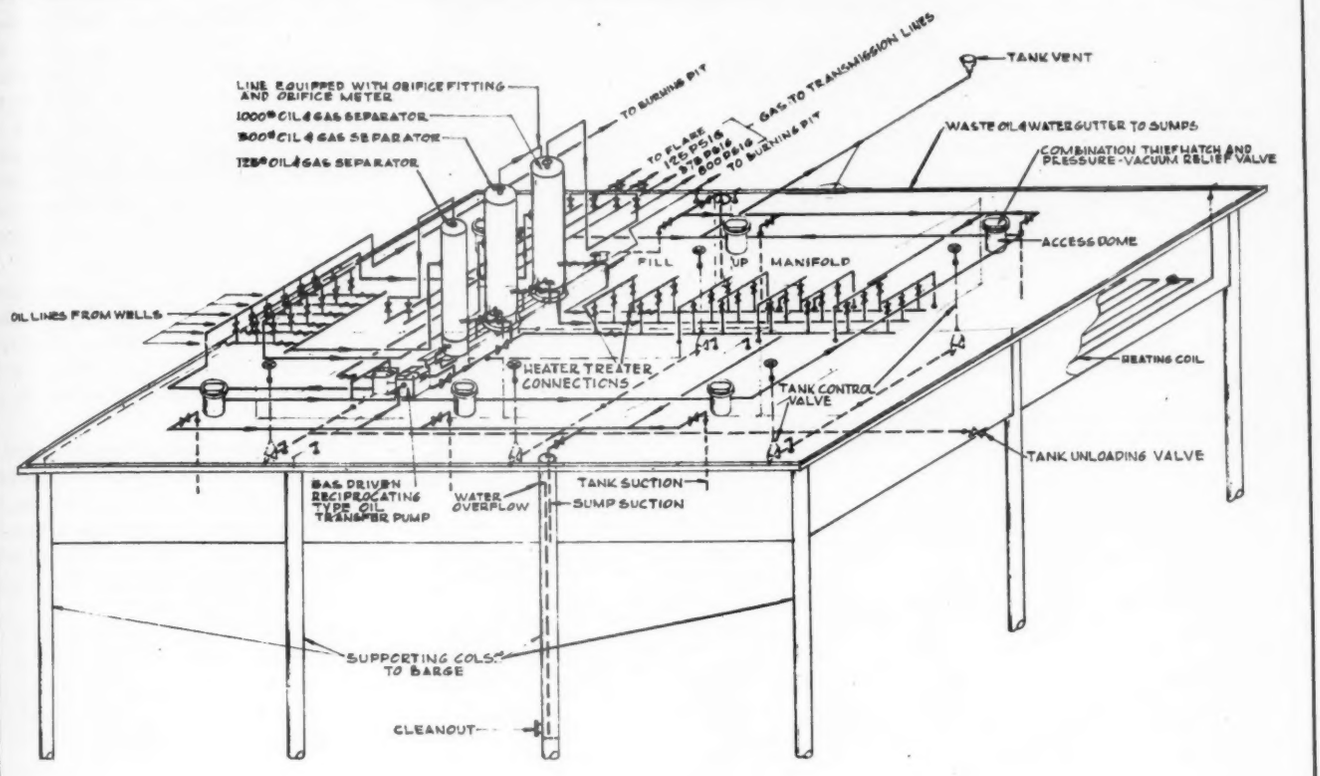
A long-felt need is filled by this type of barge in that it is the first practical substitute for the customary piling-supported wooden platforms erected to carry interim oil storage tanks. It is of all-welded steel construction, is leakproof and corrosion-proof, and is designed to withstand the severest action of wind and wave. It carries on its top-side deck all the necessary equipment in the way of pumps, oil and gas separators, etc., to make it a fully self-contained unit of oil-field equipment, in the same way that the drilling barge and compressor barge are permanent equipment.

In addition, the tank battery barge has the advantage of being easily moved as a unit to a new location, for it can be refloated in a couple of hours simply by blowing its four ballast tanks, using compressed air. It is then only necessary to tow the barge to its new position, sink it, and make the new line connections.

The barge is in two parts. The first part consists of a submersible float into which water is introduced through seacocks and which, when submerged, rests upon the floor of the bay as a kind of foundation for the storage tanks. Upon this float are erected 12 tubular steel columns, each 20 in. in diam. These columns support the second part of the barge, which is the oil storage tank superstructure with its topside oil and gas handling equipment.

The float is 80 ft by 52 ft by 5 ft. It is divided into 4 watertight compartments of equal size. When submerging, these compartments are flooded by means of a seachest with strainer, a 6-in. non-rising gate valve to control flooding of each compartment, and a 6-in. pickup line to each compartment. Extension rods lead from each gate valve to the deck, where hand wheels are provided. There is an access manhole and ladder to each ballast chamber.

To submerge, the forward ballast tanks are flooded first so that the float sinks endwise. The back tanks are then flooded and the float comes to rest gradually on the bottom. The pro-



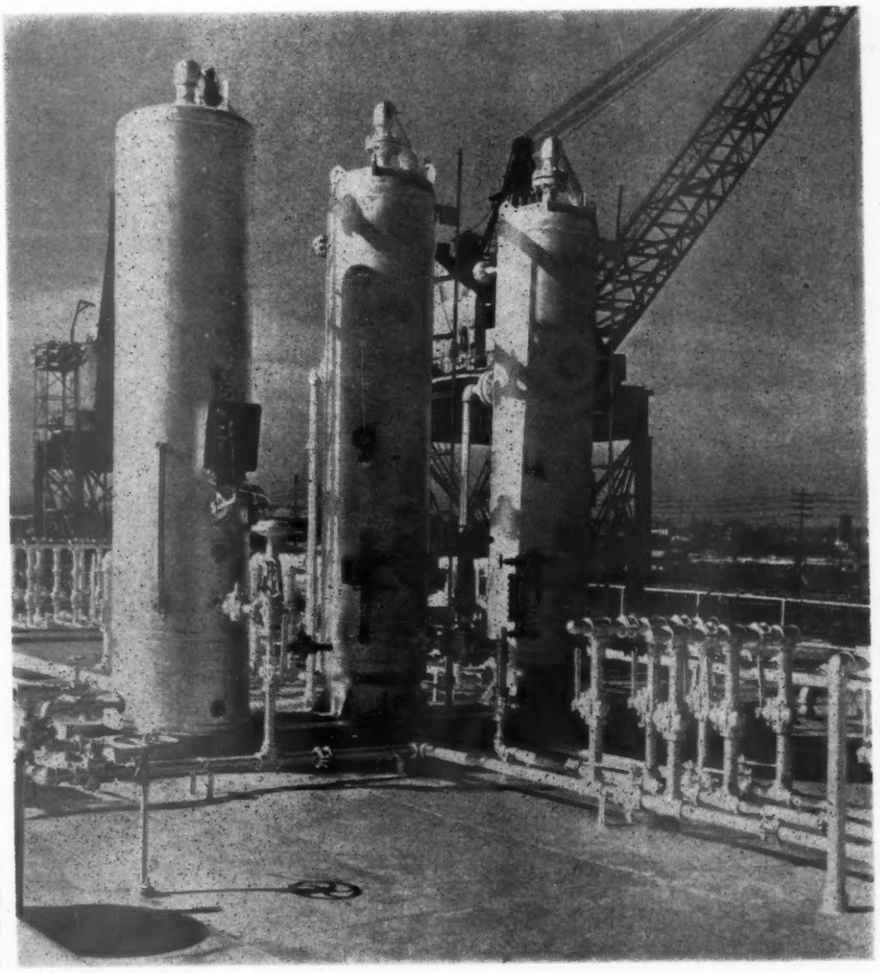
OIL STORAGE TANK BATTERY

cedure is reversed when refloating. All risk of capsizing is avoided by this method.

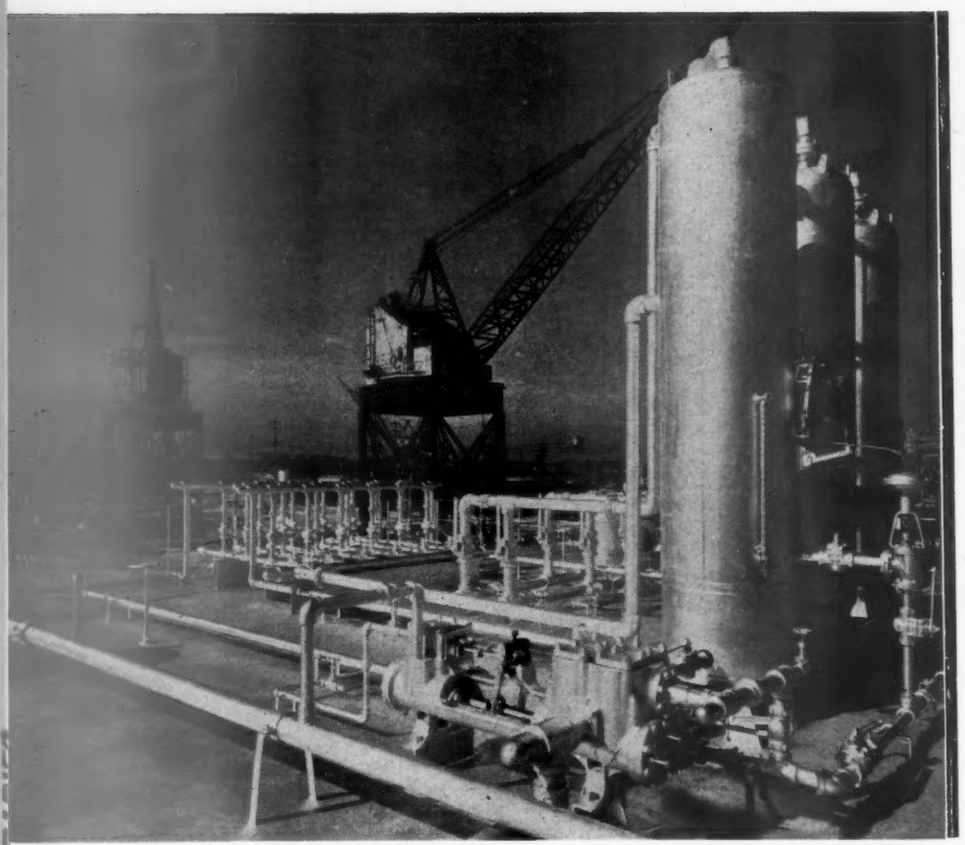
When refloating, air from portable compressors situated on the deck vents the water ballast through two of the center-line columns, which are provided with 6-in. goosenecks. These goosenecks may be removed if it is desired to fill the tanks by hose, and each has an air hose fitting on a bolted flange for blowing the tanks.

The float is constructed of 5/16 in. steel plate on bottom, top, sides, and ends. The longitudinal watertight bulkhead is also of 5/16-in. plate. Quarter-inch plate is used for the transverse bulkhead and the swash bulkheads. The float is designed to resist water pressure up to 13-ft head, internal air pressure of 5 psig, and bottom pressure of 500 lb per sq ft.

Of the 12 columns, the two centermost are fabricated of ½-in. steel plate, the others of ⅜-in. plate. Their upper and lower ends are built into the oil storage tank superstructure and the float barge, respectively.



Oil and gas separators, which are part of the handling equipment installed on the superstructure of the barge.

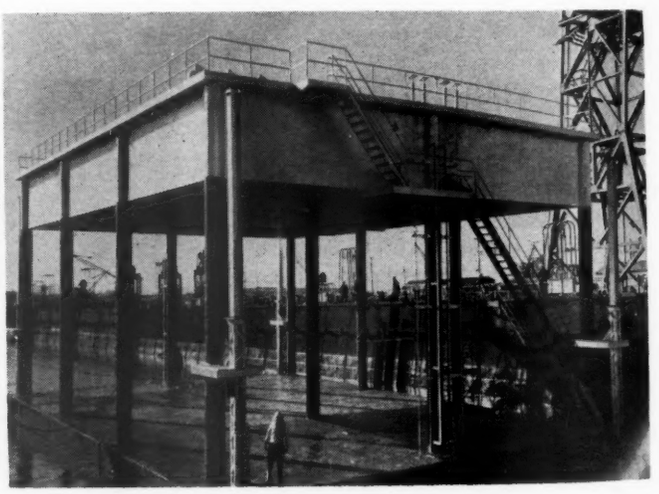


Showing the gas-operated oil pump installed on the top deck of the oil storage tank battery barge.

The oil storage tank structure consists of 5/16-in. steel bottom plate and ¼-in. steel plate top, sides and internal dividing bulkheads, the whole supported and stiffened so that the six compartments into which it is divided will contain adequately 4800 bbl of crude oil—800 bbl to each tank. Outside dimensions of this superstructure are 72 ft by 48 ft by 8 ft. Access to each oil tank is through a 3-ft diameter by 2 ft 6-in. high expansion dome on the deck, each dome being fitted with a combination pressure, vacuum relief valve and thief hatch, and a vertical ladder leading down into the tank.

When the float barge is submerged it will rest upon the bay floor at a depth not exceeding 12 ft. The bottom of the storage tank will be approximately 12 ft above the water and the oil will be run by gravity through hoses into transportation barges.

When the unit is "on location" it is anchored in place by means of 4 spuds, one at each corner. These spuds are made of 35 ft lengths of 10-in. wide flange 60-lb steel sections, each operating in a cage. Each is equipped with a 5-ton capacity hand-operated



Demonstrating submersion of the tank barge, which is here shown ready for opening of seacocks.

Below, barge is in process of submersion. Below right, oil storage tank battery barge rests on bottom of drydock at completion of demonstration of submersion.

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winch run with 30 ft of ½-in. stainless steel wire rope for the purpose of retracting the spud when it is desired to move the barge. The upper 15 ft of each spud is equipped with flat steel lugs on the web to engage a jack for breaking loose from the bottom.

On the topside deck the oil and gas handling equipment supplied by the customer, Gulf Refining Company, is situated. Included are one 7 by 4½ by 10 ft oil pump capable of operating under 200-psig gas pressure; one vertical oil and gas separator for 125 psi working pressure, 3 ft by 13 ft, with all necessary controls; one vertical oil and gas separator for 500 psi working pressure, 2 ft 6 in. by 12 ft 6 in., with all controls; and one vertical oil and gas separator for 1000 psi working pressure, 2 ft 6 in. by 12 ft 6 in., with all controls.

All deck piping, valves, bypasses, etc., were supplied by Gulf Refining and installed to its specifications. The accompanying drawing shows how the oil and gas are routed.

Bethlehem provided a 2½-in. suction line from a 4-in. pump suction header to each of two sumps, installed in a 20-in. column on each side of the barge. These sumps catch the deck drainage channeled to them by a deep gutter surrounding the entire deck. They are fitted to act as oil and water separators, with overflow piping installed to vent the water and pump lines for recovering the oil.

Steaming coils of the hairpin type also were provided in each of the 6 storage tanks, approximately 270 lineal ft of 1-in extra heavy seamless steel pipe being bolted to the tank bottoms. Deck connections were provided to each.

A platform is provided at one end of the barge slightly above water level to which a railed stairway gives access. Here is installed the oil tank drainage valve. There is also a ladder from the deck to the barge deck attached at the other end of the barge. The entire top deck is enclosed with a substantial railing.

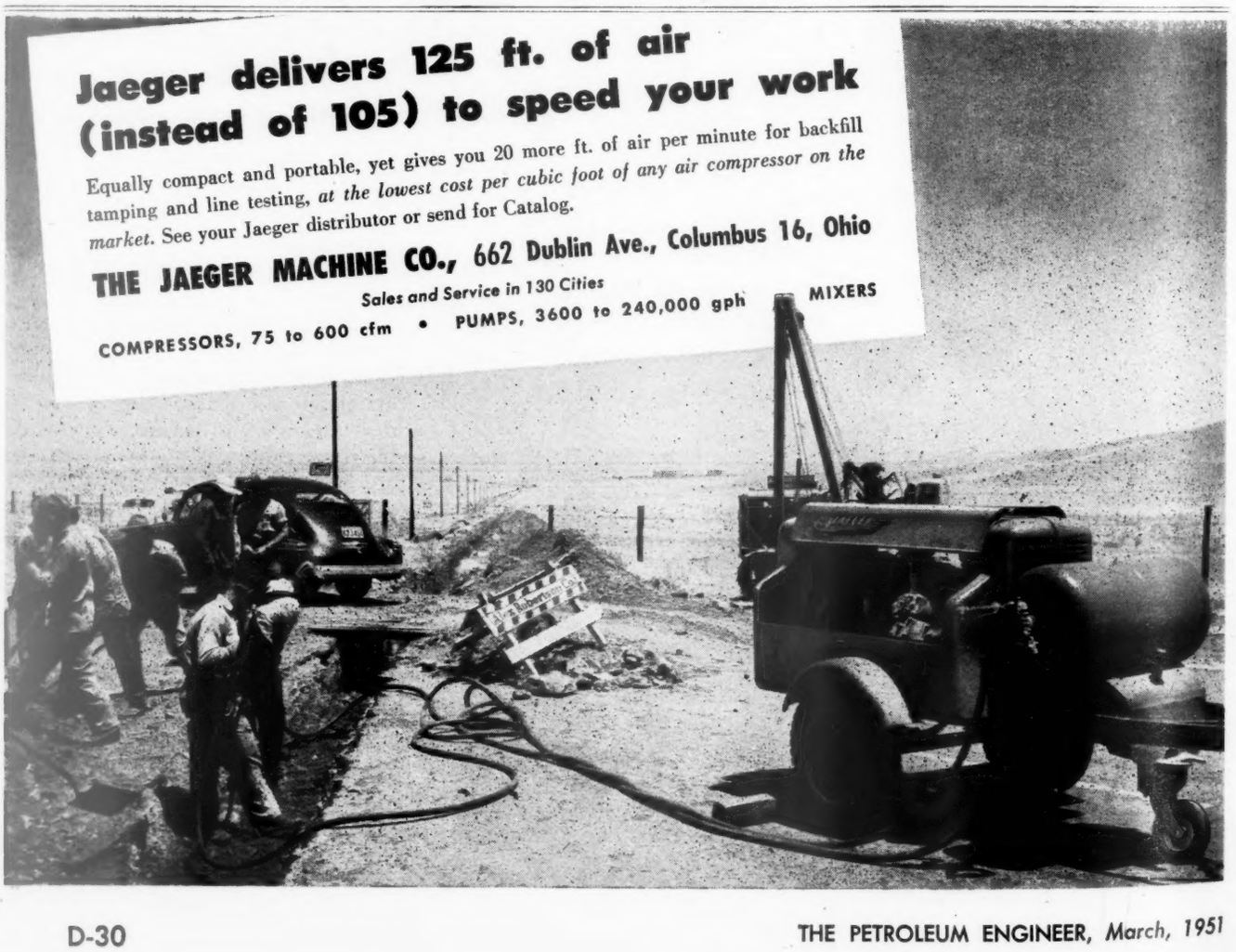
One of the important functions performed by the barge is insuring that oil does not reach the water of the bay. As it is said by the Fish and Game Commission that slicks on the water caused by spilled oil kill sea life, and as the consequences of permitting a slick to form are drastic fines and other penalties, the nonleaking feature of the new barge promises to be a great benefit to oilmen and sportsmen alike.

Beaumont Yard is already at work on other oil storage tank battery barges, these for Atlantic Refining Company. ***

PAR Program to Spend $1,700,000

The committee on promotion, advertising and research (PAR) of the American Gas Association recently approved expenditures of nearly $1,700,000 for the gas industry's coordinated programs in these fields for 1951, Norman B. Bertolette, president, The Hartford Gas Company and chairman of the PAR Committee, announced. Funds are contributed by AGA members.

A total of $657,000 was authorized for general research during the coming year. Allocation of these funds includes $140,800 for domestic gas research; $63,400 for industrial and commercial gas research; $371,800 for gas production research, and $81,000 for general technical research. The gas research program will be carried out under the supervision of the AGA general research planning committee, headed by L. E. Knowlton, executive vice president, Providence Gas Company.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Factors to be considered in the selection and maintenance of lubricants to improve performance and extend life of engine

E. B. RAWLINS†

THE purpose of this paper is to present information relative to the properties of different types of lubricating oils so that the selection of diesel engine lubricants can be made with reasonable assurance of predicting the performance of the oil selected.

The various crudes and their refining methods, blending and compounding, engine type, service, condition and maintenance, lubricating oil type, operating temperature, filtration and maintenance, and kind of fuel used, are all factors that must be considered in this selection.

Space limitations will permit only brief treatment of some of these factors, but each is treated at sufficient length to provide a basis for selection.

No specific data will be given because each installation presents its own application and if troubles develop they usually are peculiar to the specific application. Test data is valuable for research but often troubles of a serious nature develop in the field that never show up in the usual tests.

The paper is presented with the thought in mind of presenting information that will be useful in the study of lubrication problems in the great majority of cases.

Requirements

The selection of a diesel engine lubricating oil must be made on the basis of its ability to:

(1). Provide effective lubrication. That is, it shall have good film strength so as to maintain a protective film of lubricant and prevent metal-to-metal contact and resultant wear. It must also provide an effective seal between the combustion chamber and the crankcase.

(2). Resist corrosion. It must not be corrosive to bearing metals or other engine parts.

(3). Provide long useful life. That means it must be stable and resist those reactions that cause an oil to deteriorate.

(4). Keep an engine commercially clean, which means it must keep the normal deposits to a minimum and keep the engine crankcase washed down. Natural or added detergents impart to oils their ability to provide this function.

To meet these requirements, oils must possess the following basic properties:

(1). They must be stable. That is be resistant to oxidation and the consequent products of oxidation—varnish, sludge, corrosive acids, etc.

(2). They must have high film strength to provide an effective seal, prevent metal-to-metal contact of the moving parts with resultant scuffing or seizure, and carry high unit loads. They should possess a high oiliness factor and adhesive qualities so as to provide a continuous stable oil film of high anti-friction that will not break down.

(3). They should have a pour point low enough to assure good flow under the coldest conditions of operation.

(4). They should possess a low carbon content so as to minimize deposits from this source.

(5). They should have good detergency, good solvent properties, and good dispersion, natural or added. capable of removing the products of oxidation of the oil and deposits produced by the burning of the fuel and keeping these materials in suspension where they can be, for the most part, removed by the filters. Finely divided carbon particles in a collodial state cannot be filtered out nor can the oil soluble products of oxidation be removed by normal filtration.

(6). They should be resistant to foaming.

Although the physical properties cannot assure that the above conditions will be met and are no guarantee of an oil's quality, they are important as guides in the selection of a lubricating oil and a brief explanation of the principal ones and their relative importance follows:

(1). Gravity, API, gives an indication of the type of crude from which the oil was refined.

(2). Viscosity is a measure of the fluidity or body of an oil at a specific temperature. It is important because on the viscosity depends the character of the oil film.

(3). Viscosity index is a measure of the rate of change of the viscosity of the oil which changes in temperature. It is important in determining whether or not the oil selected will have good viscosity at the temperatures at which it will operate.

(4). Pour point is important in the selection of an oil to establish its fluidity at low temperatures.

(5). Carbon content gives an indication of the carbon depositing tendencies that might be expected from the use of the oil.

(6). Ash is a measure of the noncombustibles in the oil.

(7). Sulfur, if excessive, might tend to the formation of corrosive acids.

Sources and Processing

Many of the qualities found in a finished lubricating oil are inherited from the crude base itself, whereas others are imparted by the various refining processes.

Eastern or Appalachian crudes, better known as Pennsylvania base crudes, are paraffin base crudes and yield an oil of high quality with a high viscosity index, high flash point, high volatility, good oxidation, stability, and low oil consumption. Carbon deposits formed by paraffin base oils are hard and flinty and often abrasive under some conditions, however.

Western crudes are naphthenic base crudes and yield oils with a low viscosity index, low volatility, and low flash point and are less stable, but burn clean, leaving soft and flaky carbon deposits. They have higher oil consumption records. Some engines that are inclined to have trouble from carbon deposits of paraffin base oils,

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particularly 2-cycle engines in which the ports tend to clog up, give improved performance when naphthenic base oils are used.

Coastal crudes generally are asphalt base crudes and yield a finished product similar to those of a naphthenic base. In fact, they are classed with the naphthenics.

Mid-Continent crudes are the intermediate or balanced crudes. They yield oils that are intermediate between paraffins and the naphthenics, have low pour points and reduced carbon tendencies, and are considered by many to provide the best lubricant because most of the better characteristics of both are retained and their disadvantages minimized.

Generally, crudes above 24 API gravity are considered the paraffins and those below are considered the naphthenics.

The finished oils are mixtures of complex hydrocarbons, some of which, upon oxidation, oxidize to oil soluble organic acids, while others oxidize to insoluble sludges. Thus the types of oxidation products encountered in use is dependent upon the predominance and proportion of the various hydrocarbons in the oil.

Refining processes play an important part in the results obtained from the finished product. A review of the many refining processes is beyond the scope of this paper, however, and no attempt will be made to discuss the results produced by the different methods.

Blending and Compounding

Straight distilled lubricating oils with no treatment, other than possibly blending, should not be considered as a lubricant for diesel engines.

Further treatment of straight distilled lubricating oils, such as the solvent process for example, produce better products; but, since they are dependent entirely upon the natural qualities of the oil only to resist oxidation and contamination, they should be used only where very low operating temperatures are encountered. They have been used with success in large slow speed gas and diesel engines where operating temperatures are low.

The addition of oxidation and corrosion inhibitors to these better refined oils, particularly those produced by the solvent processes, have produced lubricating oils much better able to operate at higher temperatures.

When it is realized that the oxidation rate of lubricating oil doubles for about each 18 F of temperature rise above 135 to 140 F, it is apparent that the addition of inhibitors that retard the oxidation rate and raise the level of serious initial oxidation will produce oils of greatly improved performance. Oils with a normal temperature-life balance of 140 to 150 F have, with the addition of inhibitors, shown temperature-life balances of 180 to 190 F and above.

The further compounding of these lubricating oils with detergents and various other agents or additives produce the heavy-duty oils required for our heavy-duty, high output diesel engines of today. Percentage concentrations of these additives vary with different lubricating oils, depending upon the base stock and the type of service the oil is expected to encounter. Standard heavy-duty oils have concentrations varying from 3½ to 5 or 6 per cent, Supplement 1 or Series 1 oils have concentrations varying from about 7 per cent to as high as 12 or 15 per cent, while Supplement 2 or Series 2 oils have concentrations of 14 per cent and may run as high as 20 to 25 per cent.

A few words about these additives or agents will provide an understanding of their function and usefulness.

Oxidation and corrosion inhibitors, usually sulfur or phosphorus compounds, made oil soluble by some hydrocarbon or its derivative, act to retard the oxidation processes, thereby reducing the tendency to the formation of corrosive acids, varnish, and gums.

Detergent-dispersants are metallic soaps, usually calcium, barium, or potassium. The carriers for these metals are organic acids that appear in numerous forms, but all are forms of one or the other of the following general classes: Carboxylic, phenolic, organo-phospheric, or sulphonic. Detergents and dispersants, usually combined in the same additive, perform separate functions. The detergent functions as a solvent and washing medium, loosening and washing away accumulating deposits and dirt, and tends to retard their formation; while the dispersant acts to keep fuel soot and small insoluble particles and dirt in suspension as they are washed down, and prevent their coagulation.

Anti-foam agents, generally silicon derivatives of some kind, are added to the oil to prevent foaming tendencies brought on by the addition of the other additives to the oil.

The above additives are those usually found in most heavy-duty oils; however, there are many others that are used, some of them for the improvement of existing qualities and some of them to impart to the oil special properties for specific services. Among them are viscosity index improvers, pour depressants, extreme pressure agents, oiliness agents, rust preventives, etc.

It should be pointed out here that additives are not a cure-all, for although a fairly good lubricant can be produced from an inferior oil by the addition of the proper additives, an oil for high-output, heavy-duty, diesel engine service must be made from the best stocks available if good performance is to be expected.

Diesel Lubricating Problem

The modern diesel engine in its many designs and types presents varied problems to the lubrication engineer.

The large slow speed diesels do not present the troubles from heat that are encountered in the medium speed types and they in turn do not equal the high output, high speed units in dirt and oxidation problems. Also the 2-cycle diesel engine presents different problems than does the 4-cycle.

These engines operate on a variety of fuels from high grade distillates to heavy residuals, and use both solid injection and air injection fuel systems.

In the matter of lubrication they are all on common ground. They all need a good lubricant, designed to give maximum performance and service.

Lubricating oils in service in any diesel engine are subjected to heat, varying with the type, size, and service. They are subjected to contamination from dirt from non-petroleum products, from the soot and products of combustion and oxidation, and from water and fuel dilution.

Heat is the worst enemy of a lubricating oil. High temperature operation accelerates oxidation and break-down of the oil, and unless it is controlled by the retarding influence of oxidation inhibitors, a very short useful life can be expected. Straight mineral oils and even inhibited oils cannot be expected to cope with the complex products inherent in diesel engine operation. Lubricating oils fail because of this heat and resultant break-down. To explain what happens when oils become contaminated and deteriorate and eventually fail, it will be necessary to review some of the reactions that take place.

As lubricating oil is exposed to air at temperatures encountered in diesel engine operation, the oxygen in the air combines with some of the hydrocarbon molecules. Usually this initial combination causes the oil affected to form acids that may be corrosive.

Further oxidation results in these acidic parts becoming oxyacids, which have a thick, tarry, varnish-like consistency and eventually, if not both-

ered, become an insoluble sludge. They form the base for most engine deposits and deposit as sludge in the bottom of the crankcase, or as varnish on accessible engine parts. The greater the heat the faster this reaction takes place. It probably takes place faster on the piston skirt and in the ring belt area than in any other place in the engine, due to the higher temperatures in that area. Sludge of this type is known as a high temperature sludge.

An engine that normally would give little lubricating oil trouble can suddenly make a lot of varnish and sludge if it should develop a hot spot, such as a bearing running unusually warm, a piston running hot, or the oil temperature permitted to rise above a safe normal operating temperature. Such cases will have to be charged to carelessness, poor maintenance, or design failure.

In addition to the products of oxidation of the oil itself, lubricating oil becomes contaminated with dust and outside matter brought in with the intake air, fuel soot, which is finely divided carbon, carbon from the burning of the oil itself, resins and gums from the fuel, unburned and partially burned fuel, and water.

Water, unless it is condensate from too cold operation, is a maintenance problem and indicates a leak somewhere. Water from condensate from low temperature operation will emulsify and form sludges similar in appearance to high temperature sludges. These are the thick sludges usually found in very heavy thick layers all over the inside of an engine. When deposited they resemble a very thick tar or asphalt.

Fuel dilution or contamination is also a maintenance problem as excessive fuel in the oil indicates a leak or faulty functioning of the fuel system.

A product of combustion of the fuel is carbonic acid, which is mildly corrosive. This acid results from the combination of water, a product of combustion, and carbon dioxide, also formed during the combustion process. This condition is more prevalent during periods of light loading and idling.

Contaminants where high sulfur fuels are used are the sulfo-compounds, of which sulfuric and sulfurous acids are two. These acids, like the carbonic acid mentioned above, are the result of the combination of the sulfur in the fuel and the water, either produced during the combustion process, or condensate. It likewise is worse during periods of light load operation and idling.

One more type of deposit should be mentioned, the granular or coffee-ground type of deposit. This deposit is now generally conceded to be the result of adding fresh cold make-up oil to the hot used and oxidized oil. The granular deposit is the result of the fresh oil curdling the used oxidized oil.

Consideration in connection with studies of oil oxidation must also be given to the catalytic effect of the materials from which the engine itself is constructed. Iron, copper, and lead are the best catalysts of the materials, with iron being the best of the three. In any new engine, iron oxide, iron dust, fuzz on the machined surfaces, and particles removed during operation, combine to provide an excellent catalyst to accelerate the oxidation processes. Filtration will remove many of these, but it is suggested that the initial oil change be made after the first 200 to 300 hours of operation in order to eliminate as much as possible these oxidation accelerating media.

The functions of lubricating oil additives have been mentioned earlier in this paper. Space does not permit going into detail as to how they perform their functions; however, a brief explantion of the action of the detergent-dispersants will illustrate their value in lubricating oils. The detergent compounds act as solvents to dissolve gums and lacquers and prevent their deposition. They react with the oxy-acids to prevent their polymerization and make them soluble in the oil. The action of the dispersant is to carry in suspension the oil insolubles, colloidal carbon, and other finely divided particles, and prevent their deposition. The detergent-dispersants, briefly, then are designed principally to render harmless the products of oxidation that are always present in any lubricating oil in a more or less degree, depending upon whether it is an oxidation inhibited oil or one containing no inhibitors.

With the use of detergent oils it should be borne in mind that:

(1). They must be operated at higher temperatures than many are in the habit of using. Many detergents do not reach their full activity until temperatures of 180 to 190 F have been reached.

(2). Ample oil should be circulating to take advantage of the detergent action. That is, there must be a good washing action to carry away the dirt as it is formed.

Fuels enter the lubrication picture because of their many types and the different deposits resulting from their use. Often the lubricating oil is blamed for troubles that the fuel is responsible for. Three general classes will be briefly reviewed:

(1). Straight distillate fuels with a low sulfur content as a rule give comparatively little trouble from deposits. Lubricating oil requirements of engines, using a fuel of this type, are not severe in normal operation. Straight mineral oils, oxidation inhibited, have given good service with the larger, slow speed engines; but for the high speed, heavily loaded engines, heavy-duty detergent oils are required for best results.

(2). Distillate and cracked fuels containing more sulfur definitely require heavy-duty detergent oils, and if high in sulfur, require the heavier concentrations of additives of the Series 1 or 2 lubricants.

(3). The heavy and residual fuels are as a rule very dirty performers and should always use the detergent oils.

Most 4-cycle engines can operate better on paraffin base oils, with lower oil consumption. These high viscosity index oils have better wearing characteristics because they maintain a heavier oil film under conditions of heat and thus are better able to prevent scuffing and scoring; however, under high output conditions naphthenic base oils, because of their clean burning characteristics and their tendency to leave their carbon deposits soft and flaky, may be more desirable. Oils from the Mid-Continent crudes, properly refined, due to their balanced, middle of the road features, probably can be called the best all around lubricants and have the widest application for all types of operation.

The 2-cycle engine generally is committed to naphthenic oils because port clogging tendencies from carbon deposits are materially less than with the paraffinic oils.

Lubricating Oil Maintenance

The maintenance of a lubricating oil is of prime importance if long life, good performance, and low wear rates are to be expected.

Proper filtration removes from the oil, solids and abrasive material and a great deal of the gums and resins, and neutralizes much of the acid content.

Good filters of the cotton waste, cellulose, cotton spool, paper, and resin-impregnated paper and felts do an efficient job of keeping the oil clean. They will not, however, remove the supended collodial carbon. It is this carbon, mostly fuel soot, in suspension that gives the oil its black color after a short period of operation. This color in no way impairs the oil's lubricating qualities and does not indicate that it has oxidized or broken down.

The use of Fuller's Earth filters with heavy-duty detergent oils is not a recommended practice. Although they

have the ability to remove most of the contaminants in the oil, including the collodial carbon, and materially reduce the acidity of the oil, they also by the same token remove the additives from the oil. In fact, some of the additives are completely removed in one pass through the filter. All filters, however, remove some of the additives but the percentage is small and what they do remove are spent and of no further value.

Full flow filtration, where all the oil is filtered each time it is circulated, will give the best possible job of filtering. Cost of equipment and space limitations are the principal reasons for the limited use of this filtering system. Bleeder or bypass filtering, where about 10 to 15 per cent of the oil flow is filtered continuously, is the system in most general use today, and, although an excellent filtering job can be done by this system, it can never approach a full flow system as an optimum dirt level in the oil is reached, below which the bleeder system is incapable of going.

Investment in ample filtering equipment is one of the best, if not the best, method for reducing engine wear rates, improving the lubricating oil life, and reducing engine maintenance and maintenance costs.

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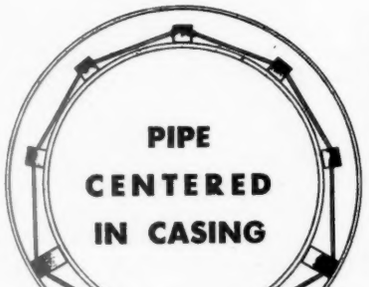

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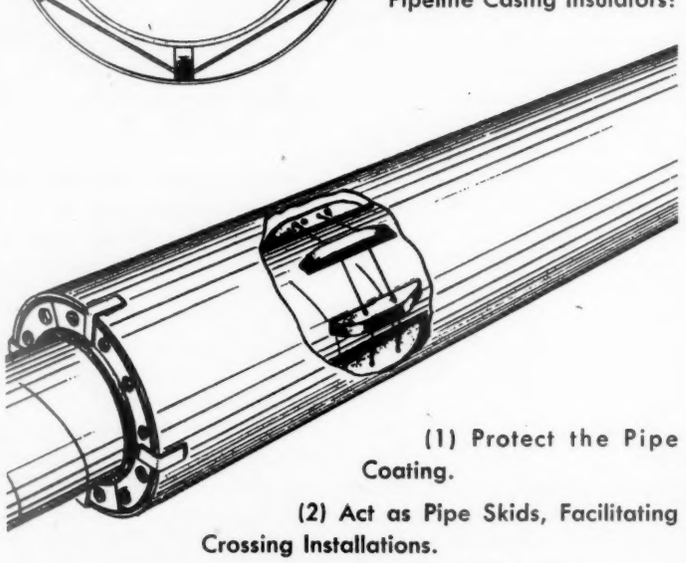

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Oil Changes

The question of when to change oil is often asked and often sidestepped. One operator will base his oil changes on a rise in its acidity, as indicated by periodic checks of its neutralization number. Another may use precipitation as a guide, or precipitation in combination with the neutralization number. Still others may use periodic laboratory checks of the oil's condition.

It is difficult if not impossible to establish any set rule for oil changes as there are so many factors to consider in the condition of a used oil, that affect its future usefulness, that a review of these various conditions and a short discussion of their relative importance will be helpful in establishing a basis for oil changes.

Operating conditions, service, type and size of engine and its individual application are all contributing factors that influence the useful life of a lubricating oil.

When lubricating oil breaks down it undergoes a rise in viscosity. This rise in viscosity is the result of oxidation, which has produced in the oil heavy oil soluble products. The more oxidation, the more of these products are dissolved in the oil and the greater the viscosity rise.

Some oils require changing when this rise is as little as 200 SSU, whereas others still perform satisfactorily with a rise of as much as 500 to 600 SSU. Experience with the individual oil is necessary to determine when it is no longer safe to use.

Where excessive dilution is present in a lubricating oil its presence often counteracts any rise in viscosity and sometimes becomes so great that a drop in viscosity is noted.

Viscosity rise is gradual and depends upon oxidation to bring it about, and under the heat of engine operation some oxidation is always occurring, although with good oils, good maintenance, and good operation, the process is slow.

It therefore is reasonable to expect some viscosity rise, the permissible amount being determined as mentioned previously; so any lack of rise or drop in viscosity should point to dilution, and a check for faulty injection equipment or leaks in the fuel system should be made.

Dilution should always be kept to a minimum and amounts in excess of 4 to 5 per cent calls for the immediate oil change and correction of the cause.

Viscosity rise will occur in all oils in varying degrees, be they straight mineral, inhibited, or heavy-duty detergent types.

The check for viscosity rise and

checks for dilution may be quickly and easily made with a Visgage by operating personnel. Other checks of oil condition require laboratory analysis to determine their status. Viscosity checks are a good indication of when further laboratory inspections are required.

Neutralization number is a measure of the acid condition of the oil; however, this test does not indicate whether acids are corrosive or not. Neutralization number checks require laboratory procedure for accuracy.

New oils usually have a neutralization number of about 0. Oxidation will cause the oil to become acid and the neutralization number to gradually rise, a number of 1½ being generally accepted as the limit of acidity that should be permitted in an oil in service. An oil change is indicated when this point is approached.

The heavy-duty oils and particularly the super-duty oils such as the Supplement 1 and 2 Series, however, are often basic or alkaline and, as such, have negative or minus neutralization numbers in some cases as high as minus 5.

For this reason, when using oils of this type, the practice of using the neutralization number as one of the guides for indicating when an oil change should be made is no longer of much value. Relative values do not mean too much, as in many cases a change of 1½ will still leave the oil alkaline or neutral and yet acid has been absorbed in an amount that would demand an oil change with an oil that was neutral to start with. Therefore, with these oils, other means must be resorted to, to determine the time for oil changes. Depletion of the detergent has been suggested as one basis for determining the useful condition of the oil.

It is, therefore, important to know the neutralization number of the new oil before establishing this factor as one of the bases for changing oil.

Precipitation is a measure of sediment and insoluble products of oxidation in an oil. Precipitation numbers are important in that they reveal to some extent the amount and degree of oxidation that has taken place in the oil. A precipitation number of 1 is considered the maximum allowable in good practice.

Thus we have a basis for oil changes:

(1). Viscosity rise. This factor may be used as a guide for further laboratory checks.

(2). Dilution. Dilution should not exceed 5 per cent.

(3). Neutralization number. This number should not exceed 1½.

(4). Precipitation number. This number should not exceed 1.

The manufacturer of a lubricating oil is always willing to assist in checking his products' condition and advising when further use is not advisable.

In theory it should, perhaps, never be necessary to change oil. Let's take an example and assume a 1000-hp engine with a sump capacity of 300 gal. Let us also assume that the engine has good maintenance, is equipped with a good filtering system that will keep the oil clean, runs 24 hr a day, and has an oil consumption of 4800 hp-hr per gal. This engine will consume, then, 5 gal of oil per 24-hr day, or 300 gal in 60 days. This means that the engine will have a complete change of oil in 60 days. Thus then, if the contamination is removed as fast as it is made and the oil maintained in a continuously clean state, an optimum condition of the oil should be reached, below which it should never go, in which case draining should never be necessary except in case of an accident such as excessive fuel dilution or water.

Reclaiming Methods

Reclaiming methods are being used more and more where the amount of oil used is sufficient to justify the investment in the equipment. These systems consist of a vaporizer and filter. The vaporizer drives off any water

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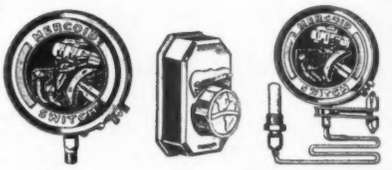

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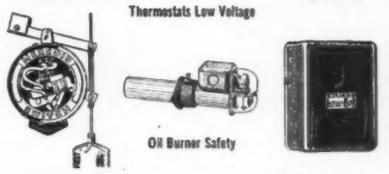

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and light ends from fuel dilution, after which the oil is filtered, often through Fuller's Earth. If Fuller's Earth filters are used, the additives are removed and the oil must be refortified with the straight additives or mixed with new oil having a heavy additive concentration. One method is to mix 4 bbl of reclaimed oil with 1 bbl of new oil with a 5 times concentration of additive.

In concluding this review of problems of diesel engine lubrication, their causes, and some suggested aids to their elimination, the writer suggests the following points be considered in the selection and maintenance of lubricating oils for diesel engines, in the interest of improved performance, reduced maintenance costs and long engine life:

(1). Use only those oils that are fortified to combat the heat and deposits common to all diesel engines.

(2). Select oils that will keep your engine clean. Detergent oils are designed to do just this.

(3). Select oils with a high viscosity index for low oil consumption and greater stability, or if the characteristics of the naphthenic base oils are indicated, select the highest viscosity index oils that the naphthenic base stock will provide.

(4). Select oils compounded of high grade stocks and low carbon content.

(5). Select oils of the proper viscosity for diesel engine service. SAE-40 oils have been found to be, generally, the most satisfactory for heavy duty service.

(6). Select oils in the Supplement 1 or Supplement 2 class for engines using high sulfur fuels or making an excessive amount of dirt.

(7). Select oils of heavier viscosities, high viscosity index, higher additive concentration, and highest quality for high output engines. The higher heats and heavier loads require oils with heavier body and greater fortification.

(8). Increase operating temperatures. This gives the detergents an opportunity to operate efficiently and reduces the chance of contamination by water condensate. Temperatures of 170 to 190 F are regarded as safe for modern lubricating oils.

(9). Provide adequate filtering for the oil. Full flow filtering is the best but a well designed bleeder or bypass filter system will provide good filtering.

(10). Use only the oil selected (do not mix with other oils). Be sure that it fits the engine and service, take care of it, and good performance and long life can be expected. * * *

Promotions Announced By Tennessee Gas

Charles S. Coates, vice president of Tennessee Gas Transmission Company, has announced the following personnel changes:

O. H. Moore, former superintendent of compressor stations, has been appointed director of engineering research. Process Engineer R. V. Mertz replaces Moore as head of the compressor department. Chosen superintendent of gas control was Tom K. Davis, former chief dispatcher. Moved up from assistant chief dispatcher to handle Davis' duties was Billy M. Rogers, while Melin Schultz became general dispatcher.

In the company's sales department, former Sales Representative Richard L. Jones was promoted to manager of the section, Vice-President N. W. Freeman announced.

On January 1 definite branches of engineering were established in the engineering department. Under the new set-up, the following groups were organized:

Civil engineering: C. A. Duprel in charge, W. J. Finley, R. J. Baldwin, and M. G. Bechtol.

Electrical engineering: H. L. Ingram in charge, W. W. Williamson, and R. O. Parker, Jr.

Mechanical engineering: B. R. Keller in charge, D. M. Taylor, and T. S. Park.

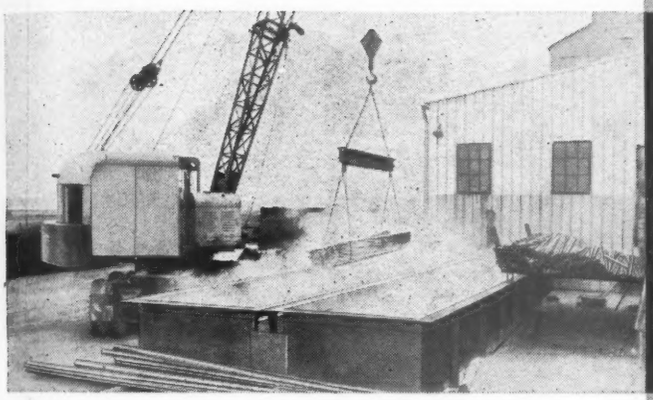
Other departmental changes in personnel and their new titles were: A. D. Cameron, assistant supervising engineer; W. P. Nickels, chief mechanical draftsman; Maurice Williams, assistant chief mechanical draftsman, and R. D. Pyle, head of material control.

Engineer Ray Garrigus has been transferred to the industrial relations department, Houston, to become the company's safety engineer. He fills a vacancy created by the promotion of Frank Smith to Division "A" superintendent.

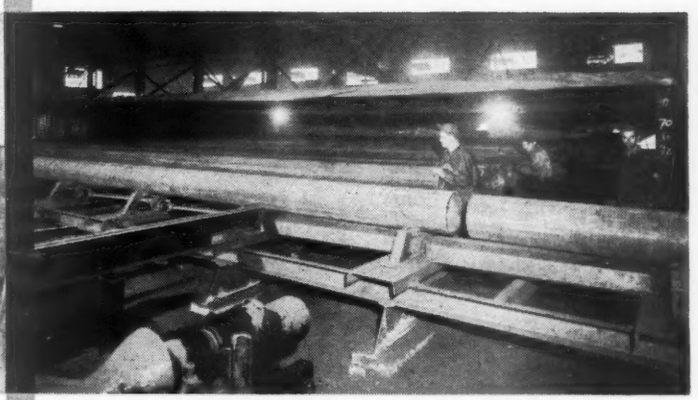
Odessa Contracting Firm Changes Name

McVean and Roberts, pipe line contractors of Odessa, Texas, have changed the firm name to McVean and Barlow. The company also is receiving its mail at a new postoffice box number: 151. This concern is a partnership composed of J. A. McVean, A. K. Barlow, and N. W. McVean. Offices and warehouse are on the Kermit Highway.

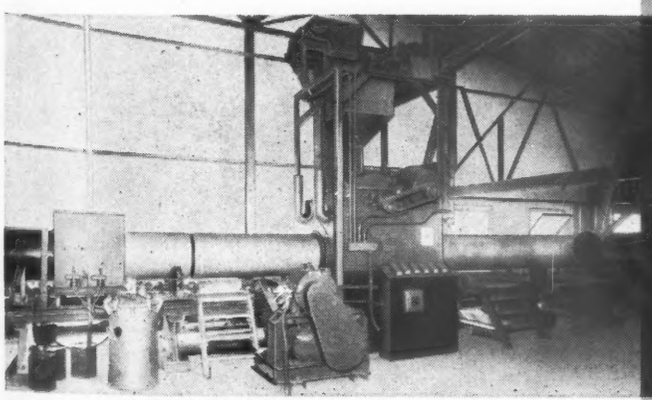
Is your pipe protection this good?



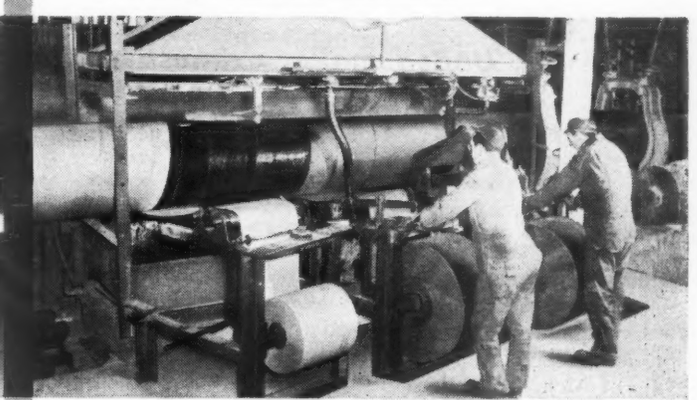
Is your pipe dipped in hot caustic solution to remove cutting oil or grease, then rinsed in clear hot water? Pipe coated by HILL, HUBBELL is!



Is your pipe pre-heated to 90° F. to remove every trace of moisture, and kept at that temperature through the entire cleaning, coating and wrapping process? Pipe protected by HILL, HUBBELL is!



Is your pipe cleaned down to the bare, bright metal by special Roto Grit Blast Process, which removes every trace of mill scale, rust and foreign matter? Pipe protected by HILL, HUBBELL is!



Are all coatings doubly applied by flow-spreading and flooding? Are all wrappings applied with perfect uniformity and positive bond? They are, on pipe protected by HILL, HUBBELL.

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P 620.91

THE PORACO IV leaves its dock and heads down the bayou seaward for another day's work. Since late last August she has been at sea almost every day the weather permitted gathering vital oceanographic data to be used in building and maintaining offshore pipe lines.

Dr. J. G. Mackin of the Grand Isle Laboratory examines a cluster of shell taken from a reef on the Gulf bottom.

Marine Studies for Off-Shore Pipe Lines

United makes exhaustive study of oceanography and related meteorology relative to proposed line from Louisiana coast.

For the last several years it has become increasingly evident that tremendous reserves of natural gas—perhaps the world's greatest—exist today under the continental shelf of the Gulf of Mexico off the coastlands of Louisiana and Texas.

During the adventuresome search for tideland oil, a number of important off-shore gas discoveries have been made and shut-in for lack of any means to transport the gas to market. In the wake of this development it has become more and more apparent that United Gas, as the world's largest handler of natural gas, would in time seek to augment its sources of supply with tideland gas and would have to explore the possibility of laying pipe lines out into the gulf.

As early as November, 1949, members of the general office engineering and research departments began working with the idea of large-diameter off-shore pipe lines. Were they practical? How costly would they be to build and maintain?

Many new and vastly different factors would have to be considered, and our research and engineering personnel knew from the outset that a full, scientific understanding of the shallow water environment would be necessary before any construction could begin. Even from the immense amount of available information on the tidelands area they couldn't be sure of all the answers. Localized and more detailed data along exact routes of proposed pipe lines were needed.

Today that information is being collected and analyzed in one of the most exhaustive studies of shallow water oceanography and related meteorology ever undertaken for a specific area. There is nothing to compare with it in the history of pipelining!

This is the story of that study. It is the story of the good ship *Poraco IV*, a sturdy 60-ft sea craft that for six months now has been maneuvering in the shallow waters of the gulf off the coastline of St. Mary and Iberia parishes, Louisiana. It is a story of oceanography and meteorology, and how they will play a key role in this new venture in modern pipelining. Waves, currents, water bottoms, shell reefs, marine organisms — almost every conceivable physical characteristic of the shallow gulf waters—are being explored to learn what effect they will have on the design, installation, operation and maintenance of submarine pipe lines.

The results so far have been remarkably successful, and United plans to go seaward with its first submarine line this year, pending approval of the Federal Power Commission. An application filed with the F P C in July, 1950, requesis authority to construct a 20-in. line from the coast of St. Mary Parish out to the Pure Oil

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drilling platform in Block 32, where one of the most important off-shore gas discoveries has been made. The proposed line will begin 3½ miles inland from the shore line and extend some 15 miles out into the gulf to reach the Pure platform.

A later application was filed in December asking for permission to extend a 14-in. line from the Pure platform approximately 12 miles farther out to Magnolia Block 45, and another line from there to Magnolia Block 110, 14.5 miles farther out in the gulf. Major gas discoveries have been made by Magnolia in both areas.

All three blocks are in the Eugene Island off-shore area, which encompasses some 1000 sq miles that have been surveyed and divided into blocks of approximately 5000 acres each by the state of Louisiana for leasing and drilling.

United first began actively discussing the problems of an off-shore pipe line in the fall of 1949. At that time a consulting oceanographer was asked to prepare a report outlining all factors that would have to be reckoned with in constructing and maintaining such a pipe line, and in May of last year this preliminary report, nearly 100 pages in length, was completed. In it were detailed analyses of weather and wave conditions in that part of the Gulf of Mexico during the last 40 years. Like the numerous theoretical calculations however, they needed to be proved by actual observations of wind, waves, and bottom conditions as they are today. Thus, in the fall of 1950 United set out to find this new data, which company engineers and research personnel knew would be necessary for such an undertaking.

The Texas A. & M. Research Foundation, which already had an excellent marine laboratory at Grand Isle, Louisiana, agreed to conduct the necessary studies. Under the technical supervision of the Department of Oceanography of the A. & M. College of Texas, the Foundation made arrangements with Oceanographic Research Services of California and other individual consultants of the Scripps Institute of Oceanography of the University of California, to put the best available talent to work on the survey.

It was a big undertaking from the start, and took intense preparations. Equipment had to be assembled, and a suitable work boat obtained. For the latter, United went to the Robert H. Ray Company, a geophysical contractor with wide experience in shallow water operations, and made arrangements to use its 60-ft *Poraco IV*, a barge-like craft often known as a "sea-mule". Powered by twin 150-hp engines and with a displacement of 55 tons, she was a logical choice for a tough job.

Probing operations were carried on to determine depth and thickness of various layers of sediment that exist beneath the sea bottom along the route of United's proposed 20-in. line. The end of the probe was about 15 ft below sea floor when picture was made.

In its Houston shipyard the Ray company refitted the *Poraco IV* for her special work and assigned a four-man crew—skipper, engineer, cook, and deck hand—to handle her.

In the latter part of August, 1950, *Poraco IV* and the research party from A. & M. began operations in Atchafalaya Bay, using The Texas Company's Horseshoe Bayou Camp, near the coast in St. Mary Parish, as a home base. The first phase of the work was to cover the route of the proposed 20-in. pipe line from the landing point out to Block 32.

The party set out to find answers to a number of problems:

How deep must a pipe line be buried beneath the bottom to insure that no storm, even of hurricane force, would scour off the backfill and expose the line to wave action?

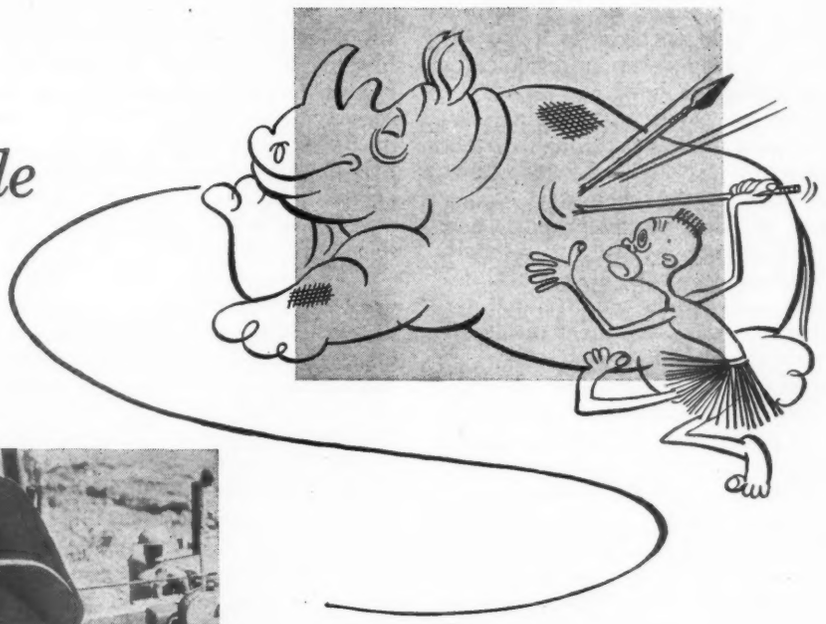
How heavy must the pipe be to insure that it will neither float out of the muck in which it is buried nor sink slowly in the pudding-like mass beneath it until the line pulls itself apart?

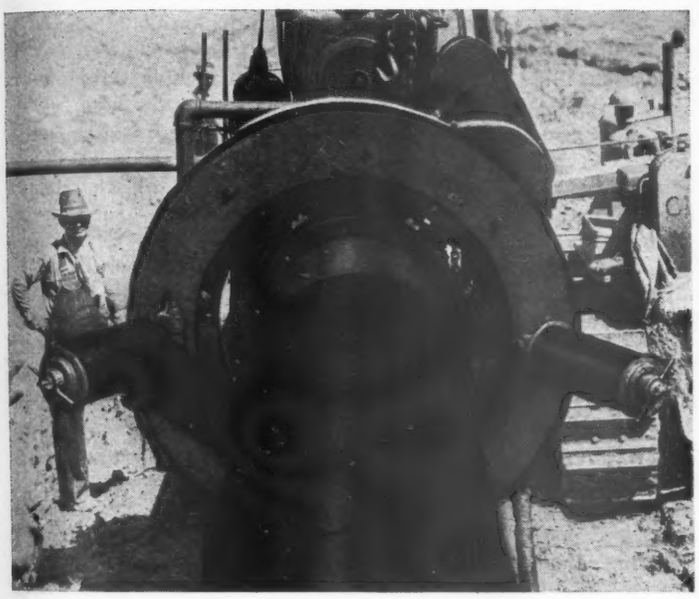
How will our usual pipe coating materials withstand sea-bottom bacteria and various chemical conditions that prevail beneath the bottom of the sea?

What type trenching equipment would be most suitable to install the line, and what should be used as backfill material?

How would currents and waves in the area affect operations once con-

Like the Rhino's tough hide that protects what's inside...





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struction got under way? What precautions could be taken to avoid situations causing delay or difficulty in constructing the line?

These are some of the big questions being answered through careful studies in the specialized fields of marine biology, the chemistry of sea water, physical oceanography, and submarine geology. An intense study of meteorology in the area is also underway since wave action and water temperatures are the direct results of atmospheric variations.

Most of the oceanographic observations are being made from the *Poraco IV*, while the majority of the meteorological data is being recorded by special instruments now installed on the Pure Oil platform.

The route of the proposed 20-in. line from a point on shore near Point Chevreuil to the Pure platform can be roughly divided into two regions, that lying inside the shell reef, which marks the boundary of Atchafalaya Bay, and the more or less open waters of the Gulf of Mexico beyond. The inner region varies in depth to as much as 6 ft at some points but abounds in shell masses that often rise to within a foot or so of the surface. Beyond the reef the water depth increases more or less uniformly to a maximum of 11 ft at the Block 32 platform.

Beginning last August 28, *Poraco IV* was at sea almost every day the weather permitted. When the technical party was working in waters close to the shore line she returned at night to Horseshoe Bayou. Farther out and when the sea was calm, she anchored for the night and both the crew and research men used her bunk facilities.

The A. & M. party conducted numerous forms of scientific investigation while aboard the *Poraco IV*. One of the most important—certainly the most time-consuming—was the coring work. At frequent intervals in the area of the proposed pipe line route cores were taken from the sea bottom to discover the types and characteristics of the sediment the line will have to rest in.

They are taken with a specially developed "split" core tube that fits inside a core barrel. After the core barrel is pushed into the bottom and brought up, the liner or tube is removed and opened up to expose the complete core lying in the lower half of the tube. Carefully slicing away half the core reveals the various layers of sediment that make up the mucky top section of the sea floor at that particular location.

Both shallow cores (0 to 10 ft) and deep cores (10 to 20 ft) were taken, depending on the location and the depth of sample needed. After preliminary examination onboard the boat they are bottled and sent to the Grand Isle laboratory for microgeological and bacteriological examination.

At each coring station a long metal probe was used to determine — by "feeling"—the precise thickness and depth of key layers of sediment that appear in the core. The core liner when opened may reveal a 3-in. layer of a certain type sediment, whereas actually the original section may have been 4 in. thick as it existed in place under the sea bottom. Compression in the core tube is responsible for this slight distortion, and the probe is used as a corrective measure. In the hands of an experienced technician it can be used to determine the almost exact thickness of each of the layers of sediment found in the core. By slowly pushing the probe downward into the sea bottom, he can tell when it leaves one type sediment and enters another by the difference in resistance. Another special type probe was also used at each coring station. Fitted with a thermometric device, it was employed to find the temperature variations in the different kinds of sediment that make up the sea bottom.

Data gathered at each coring station—from the core, the depth probe and the temperature probe—were all carefully noted for correlation and study later.

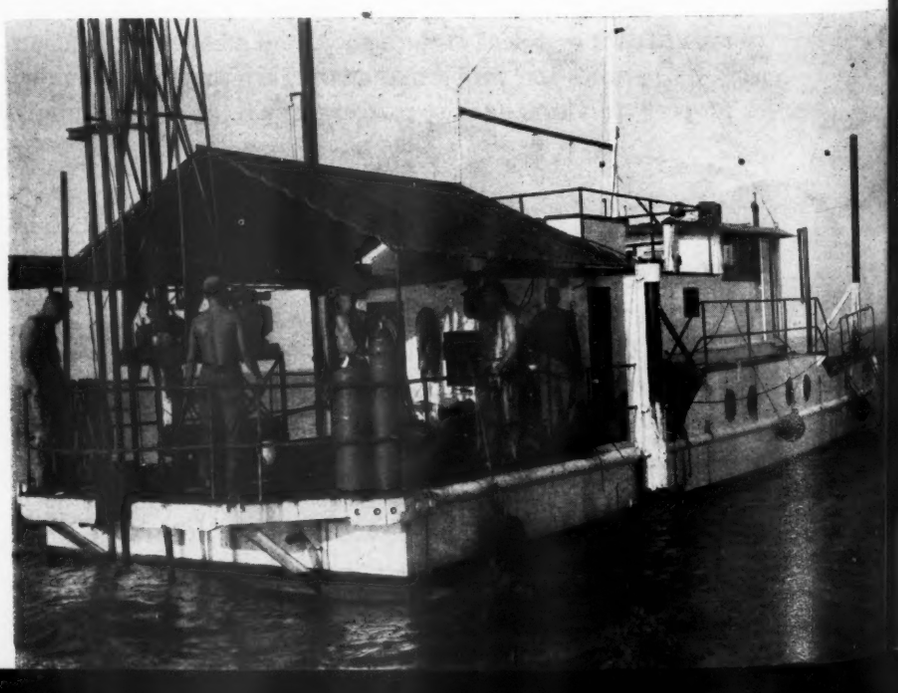
One of the most unique features of the coring work was the fact that the *Poraco IV* remained almost motionless at each location while members of the research party took cores and used their probes. Except in very bad weather, there was no pitching, listing, or movement of the boat to bother the men or the instruments they used. This was made possible by the use of four spuds approximately 30 ft long, which are fitted in sleeves on the sides of the boat. Easily raised or lowered, the spuds were dropped down into the sea floor each time stable anchorage was needed and they provided an almost stationary base from which to carry on coring and probing operations. In the words of one consulting oceanographer from California, "it was like setting a huge table down over the water to work from."

In addition to coring, the party made special studies of the shell reef along the outer edge of Atchafalaya Bay and of other smaller shell masses resting on the bottom of the bay. Depths and textures of the shell "rafts" were found by coring and probing, and samples were taken for laboratory study. In areas where the shell was piled high enough to make the water extremely shallow—too shallow for the *Poraco IV*—operations were carried on from a small tender.

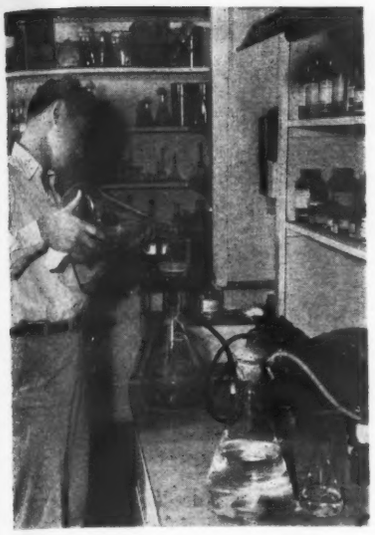
By probing, the men found that both the reef and smaller rafts of shell extended down into the muck of the sea bottom only about 12 or 13 ft and were not underlaid with any hard substances or formations that might hinder trenching for a pipe line.

Depth Gauges

Another important operation aboard the *Poraco IV* was the running of depth traverses along the proposed route of the line. An extremely sensitive recording fathometer (depth recorder) like those developed during World War II to chart shallow water areas for naval operations, was used



Coring operations consumed much of the time during the survey work. The cores were taken at frequent intervals along the route of the proposed line to Block 32, some of them as deep as 20 feet below the sea floor. The picture above is a typical scene during coring work.



Many of the studies were carried on at the Grand Isle lab. At left sea water is being filtered through a special glass filter. At right a geologist weighs and studies one of the many samples brought to the lab for examination. *H. O. Wiseman, United Gas Photographer*

to obtain an accurate record of the depth and bottom contour along the route.

The fathometer is a scientific instrument that automatically measures water depths by sound impulses. As the boat moves along, it sends out a steady stream of pinging sounds, like the striking of a bell, which hit the bottom and reflect back. The returning sound wave is picked up and electrically compared with the outgoing wave to determine how long a trip the sound wave made. Half the length of the trip is the depth at that point. The depth record itself is made on a long strip of paper, in much the same manner as electric well logs or seismic shot recordings. It provides an exact picture of the ocean floor, leaving nothing to guesswork.

Weather Studies

During October while the *Poraco IV* and her party were busy gathering vital oceanographic data, there was other activity on the Pure Oil Block 32 platform. A special instrument house fabricated in the Ray Company's shop in Houston was erected on the platform to protect the recording instruments that gather wave, tide, wind, and temperature data.

Various instruments were set up to obtain the vital meteorological information. Among them were recording meters to gauge wind velocity and directions, water temperatures, and air temperatures. A wave indicator that records the rapid changes in the water, and a tide indicator that responds only to the slower movements of the tide, are in operation continuously. Both are installed under the water but transmit their recordings up to the instrument house atop the drilling platform.

Thus the overall research program has been a three-fold operation: (1) Field work done aboard the *Poraco IV* and at the Pure Oil platform; (2) the laboratory studies at Grand Isle; and (3) analytical reports compiled at the A. & M. College of Texas and at Scripps Institute of Oceanography.

By late December the *Poraco IV* had completed the first phase of her mission—the study of that area between the shore line and Block 32—and many of the preliminary results were in the hands of United Research and Engineering departments. From these and other reports that continue to come in from the project, final plans are now being formulated to build and maintain United's first offshore pipe line.

Plenty of hard work remains before the first joint of pipe ever goes in the water, but the ground work has been laid.

Meanwhile, as construction plans for the Block 32 line are being made, the *Poraco IV* is back at work, pushing farther seaward until the greater depths of water along the route of the proposed extension to Magnolia Block 45 will make it impossible for her spuds to reach bottom. Then she must give way to a larger, faster vessel and the research party will turn to gravity coring devices and survey equipment that doesn't depend on the steady deck of the *Poraco IV*.

Acknowledgements

Acknowledgment is made to *United Gas Log*, official publication of the United Gas Pipe Line Company, for use of this material. Also to Fred Cauthron, Grand Isle Laboratory, and Warren Thompson, Oceanographic Research Services, for photographic coverage of survey operations.* * *

moving special split core tube from core barrel.

Core samples are bottled for study at Grand Isle lab.

NEWS

Texas Gas Develops New Louisiana Source

Texas Gas Transmission Corporation announces it has developed a new source of natural gas in southern Louisiana that will play an important role in the company's expansion. As a first step, Texas Gas acquired the Louisiana Natural Gas Corporation, a gas gathering system in southwestern Louisiana, which includes about 110 miles of gathering pipe lines that now distribute approximately 100,000,000 cu ft of gas a day to industrial customers in the Lake Charles, Louisiana area.

Texas Gas also has formed Texas Northern Gas Corporation, to provide a second gas gathering network in southwestern Louisiana.

O. R. Smith to Give Full Time to Welding Equipment

O. R. Smith, of Fort Worth, Texas, who has spent many years in the pipe line contracting business, announces he is liquidating the Smith Contracting Company, and in the future will devote his entire attention to the portable pipe line welding equipment that he has recently perfected. The unit is used to double-joint pipe, welding by the automatic submerged-arc method, and can be taken right out on the line. The equipment is being made available to pipe line contractors on a rental basis. For this purpose Smith is operating under the name Hauser Pipe Line Equipment, Inc.

Imperial Announces Another Large Tanker

Construction of a sister ship to the two largest freshwater tankers in the world has been announced today by Imperial Oil Limited. The vessel will be built at Collingwood Shipyards Ltd., for delivery in the spring of 1952. Cost will be about $4,000,000.

The new tanker will be similar to the *Imperial Leduc* and *Imperial Redwater*, which were launched last November at Collingwood and Port Arthur, respectively, and are now being outfitted. This spring these two tankers will begin carrying Alberta crude oil from Superior, Wisconsin, terminus of the Interprovincial pipe line from Edmonton, to ports serving Ontario refineries. The new ship will also be put on this run.

Dimensions of the ships are: Length 620 ft; breadth 68 ft; speed 13 knots; capacity 115,000 bbl on a 24-ft draught. With this capacity, each tanker can move about 5,000,000 bbl of oil in a season. Each ship will carry a crew of 36.

Richfield Puts Into Operation Important New Line

Oil to serve growing demands of the armed forces and the west is now flowing through Richfield Oil Corporation's new 14-in. pipe line linking Los Angeles with San Joaquin and Cuyama Valley fields. The project represents an expenditure of $7,000,000.

Constructed to assure economical, dependable transportation for Richfield's increasing oil supplies from valley producing areas, the line spans 112 miles of plains and mountain terrain. Completion of the final 54-mile segment between Richfield's Wheeler Ridge pump station and Newhall wound up a construction project begun 15 months ago.

The second of two Richfield pipe lines now connecting the valley area with Los Angeles, the new line roughly parallels a 125-mile, 10-inch line from Buena Vista Lake pump station, about 7 miles east of Taft, which was completed in 1925.

Completion of the 14-in. carrier with a rated capacity of 75,000 bbl a day brings total delivery capacity of the two lines to 105,000 bbl a day. Both lines terminate at Richfield's Watson refinery.

Work on the initial 58-mile section of the big line between the refinery and Newhall was completed a year ago and construction of the final link, 54 miles between Wheeler Ridge and Newhall, was begun October of last year.

Two new pump stations at Wheeler Ridge and Tejon provide power to move oil through the line. Each is equipped with three 1050-hp, supercharged, dual-fuel diesel engines, one of which will serve as a standby power unit at each station. Designed to operate on either natural gas or fuel oil, the engines will permit switching from one fuel to the other, depending on availability and economy.

One of the most modern pipe lines ever built in California, the new 14-in. line is designed for maximum efficiency. Walls of the pipe vary in thickness, being heaviest where greatest pressures prevail. This affords considerable savings in steel, Richfield pipe line engineers point out. Design throughout is in accordance with provisions of the latest publication of the American Standards Association.

Sectionalizing gates installed on either side of all major stream crossings and at other critical points in the line will prevent loss of oil in the event of line failure. The line was designed and built for the operation of scrapers. Top quality bitumastic coating protects the entire length of the line.

All engine cooling will be effected through heat exchangers, which transfer waste heat to the oil stream. Use of 16-in. pipe over 14 miles of the lines reduced by one the number of pump stations needed to move the oil.

It is planned to apply cathodic protection devices to prevent corrosion and, to that end, insulating flanges were installed at all sectionalizing gates and electrolysis test stations were installed at regular intervals.

Long radius field or shop bends were used throughout the line and line scrapers were run through the entire length, tending to increase hydraulic efficiency.

General contractors on the final section of the project were Engineers Limited Pipe Line Company on the pipe line and Refinery Maintenance Company on the pump stations. Contractors on the lower section of the pipe line were J. E. Young Pipe Line Contractor, Inc., and the Alex Robertson Company.

Rate Schedule for Interim Period Allowed

The Federal Power Commission has allowed an interruptible service rate schedule submitted by Tennessee Gas Transmission Company, of Houston, Texas, covering the company's Ohio-Pennsylvania rate zone, to take effect on an interim basis as of January 24, 1951, for the period through November 30, 1951.

The new schedules parallel the effective interruptible service rate schedules in Tennessee's other zones and continue the established practice of having a price equivalent to the firm rate at 100 per cent load factor, or about 25.1 cents per 1000 cu ft.

The FPC previously had accepted for the same interim period Tennessee's firm rate schedules covering the Ohio-Pennsylvania and New York zones. In allowing the firm rate schedules to take effect, the commission said that it was postponing determination of what constitutes "satisfactory schedules" until operating data can be obtained.

The commission's latest order said that the interruptible service rate schedules should be accepted for an interim period contemporary with the interim period for the firm rate schedule in the zone.

The rate schedules were submitted by Tennessee in response to a condition included in a certificate issued to the company in July, 1949.

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NEWS

Westcoast Transmission To Go Ahead With Plans

The decision of the Alberta Government not to allow the export of natural gas until the province's proved gas reserves are established is not in conflict with the plans of Westcoast Transmission Company, Ltd., for the eventual piping of Alberta gas to the Pacific Northwest market, says Frank McMahon, president.

"It has always been the policy of Westcoast to take gas from the area in the northwestern portion of the province which the Conservation Board said is beyond the economic reach of Alberta consumers," he said. His company's plans, therefore, do not interfere or conflict in any way with the gas requirements of the province or the findings of the board, as the only market for the natural gas found in the northwestern area of Alberta—and in the adjoining northeastern area of British Columbia—is the export market of the Pacific Northwest. Since the Alberta Government has announced itself in favor of the principle of export, McMahon stated that the policy of Westcoast is to pursue its plans.

McMahon said he was in complete agreement with the findings of the conservation board in setting aside the present proved reserves of central and southern Alberta to meet the requirements of Alberta consumers for the next 30 years.

Two New Active Members Pipe Line Contractors

O. R. Burden Construction Corporation, Tulsa, Oklahoma, and Mid-States Construction Company, Mount Vernon, Illinois, have recently become active members of the Pipe Line Contractors Association.

Oscar Burden, president of the former company, has been active in the pipe line construction industry for many years, and prior to that was connected with War Emergency Pipelines and The Texas Pipe Line Company. In addition to headquarters in Tulsa, the company maintains offices in Wichita Falls, Texas, and Shreveport, Louisiana. P. T. Thibodeaux is vice president and J. S. Burden secretary-treasurer.

Mid-States is headed by O. A. Holdren as president. Robert Webb is vice president, David Furnall secretary, Virgie Holdren treasurer, and Walstina Ayers assistant secretary. This company began operating under its present name in December, 1949, as successor to the Holdren Construction Company.

New Type Pipe Coating Machine Demonstrated

Recently a luncheon was held at the Pittsburgh Athletic Club by the Royston Laboratories, Inc., of Blawnox, Pennsylvania, for representatives of some of the leading utilities and pipe line engineering companies. After the luncheon guests were taken to New York State Natural Gas Corporation's Oakford storage pool to observe operation of the new Roskoter line travelling pipe coating machine.

This machine was invented and designed by Allen T. Perry, Compton, California, for the purpose of providing a mechanical method to apply Roskote cold-applied pipe mastics. Perry built his own spray ring and had Perrault Brothers, Tulsa, Oklahoma, fabricate to his design the other principle parts. Basically, the Roskoter is the Model "L" cleaning machine with a 22-in. cleaning head, 16 to 18-in. wrapping heads, operating on fiber rollers and powered by a Continental 226 Motor. This initial machine was designed to spray coat 20-in. pipe utilizing 18 spray nozzles to effectively spray coat Roskote cold-applied pipe mastic in a uniform film over the entire circumference of pipe in one operation. The coating can be applied to the designed film thickness by regulating the volume sprayed with the speed of the machine. This cold-applied pipe coating is fed to the spray nozzles by the Lincoln Engineering booster pump spraying from a 315 cu ft compressor. As Roskote mastic does not require a primer, the cleaning, coating, and wrapping operations need only one operation.

For the purpose of this demonstration the Roskoter applied three types of glass wrappers, one supplied by Perrault Brothers, and Glasfab and Coromat supplied by Midwestern Engine and Equipment Company, Tulsa. The Roskoter was operated by Jim Romeis of Perrault Brothers and Perry supervised the spraying.

Great Lakes Petroleum Shipments Set New High

Shipments of petroleum products on the Great Lakes during 1950 set a new high record for the fifth consecutive year.

The year's movement totaled 13,330,666 net tons, an increase of 5.7 per cent from the preceding year's 12,607,278 net tons, according to the Lake Carriers' Association.

The number of tankers in operation at the end of the season included 69 self-propelled vessels, representing an increase of three in the Canadian fleet, plus a large group of barges.

FPC Postpones Hearing On Request for Gas

The Federal Power Commission hearing on petitions of Texas Gas Transmission Corporation, of Owensboro, Kentucky, and Indiana Gas and Water Company, Inc., of Indianapolis, Indiana, has been continued from February 19 to March 21 in Washington, D. C.

The continuance was requested by Panhandle Eastern Pipe Line Company, of Kansas City, Missouri, with the Public Service Commission of Indiana and Indiana Gas and Water Company, Inc., concurring.

Texas Gas and Indiana Gas are seeking an FPC order directing Panhandle to deliver up to 12,000,000 cu ft of natural gas per day to Texas Gas at its connection with Panhandle near Danville, Indiana, during the 1950-51 heating season. The two companies also are seeking such additional quantities in the future at this delivery point as Texas Gas may request from time to time up to the full contractual obligation of Panhandle to Texas Gas of 18,000,000 cu ft per day. Indiana Gas purchases gas from Panhandle and Texas Gas.

FPC Resets Hearing Date Until May 8

The Federal Power Commission has postponed until May 8 the hearing previously scheduled to begin January 26 in Washington, D.C., on a joint application filed by Independent Natural Gas Company, of Pampa, Texas, and Northern Natural Gas Company, of Omaha, Nebraska.

Northern was proposing to acquire from Independent 21 miles of pipe line and a compressor station in Texas. The facilities are now used by Independent to supply natural gas to Northern.

Northern Natural Gas Rate Hearing Postponed

The FPC postponed until March 26 the hearing previously set to reconvene February 19 in Washington, D.C., in the proceedings involving the FPC's suspension of rate increases proposed by Northern Natural Gas Company, of Omaha, Nebraska.

Northern is proposing two increases, one of approximately $5,200,000 and the other of about $4,100,000 based on anticipated sales for the 12-month period ending October 27, 1951. Hearings on the $4,100,000 increase were recessed last October 27 to reconvene February 19. On this same date of October 27, Northern filed the second proposed increase, which subsequently was suspended by the Commission.

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FPC Postpones Hearing In Gas Service Case

The Federal Power Commission postponed until April 2 the hearing previously scheduled to begin January 30 in Washington, D.C., in the consolidated proceedings involving five applications in connection with proposed natural gas service in communities in Pennsylvania and New York.

In four of the applications the companies are seeking natural gas from subsidiaries of The Columbia Gas System, Inc. Warwick Gas Corporation, of Florida, New York, and Crystal City Gas Company, of Corning, New York, have asked the FPC to direct Home Gas Company, of Pittsburgh, Pennsylvania, to supply them with gas. Citizens Gas Company, of Stroudsburg, Pennsylvania, and Bangor Gas Company, of Bangor, Pennsylvania, are seeking gas from The Manufacturers Light and Heat Company, also of Pittsburgh. The fifth applicant, Pen Argyl Gas Company, of Pen Argyl, Pennsylvania, proposes to build a lateral between its distribution system and Bangor Gas Company's.

Manufacturers and Home had requested a postponement of the hearing for at least 60 days. The companies said they could not now determine their gas supply and requirements situation with any degree of certainty and would prefer to have the 1950-51 winter experience behind them before being placed in the situation of taking any position with reference to having new loads added to their systems.

Westinghouse Awarded Contract by Plantation

The Plantation Pipe Line Company, operator of one of the world's largest pipe lines for refined petroleum products, has awarded a $600,000 contract to the Westinghouse Electric Corporation for electrical equipment necessary for the expansion of the system.

C. R. Younts, president of Plantation Pipe Line Company, stated that the contract provides for switchgear, motor starters, control centers, and ventilating fans. The additional equipment and pipe line will boost the capacity of the system from approximately 100,000 to 167,000 bbl a day, Younts said.

The original pipe line, consisting of 12-in. and 10-in. pipe from Baton Rouge, Louisiana, to Greensboro, North Carolina, with lateral lines to Birmingham, Alabama, Columbus and Macon, Georgia, and Knoxville, Tennessee, was constructed in 1941. The system, which filled a vital need during World War II, used Westinghouse equipment throughout for main pumping equipment at all of Plantation's 31 pumping stations.

The expansion of the system to provide for a parallel 18-in. line from Baton Rouge to Bremen, and a 14-in. line eastward to Charlotte, North Carolina, can be accomplished without the addition of new motors.

"Twenty of the original 60 explosion-resistant 600 to 900-hp Westinghouse motors will provide the additional horsepower necessary for the expanded activities of the line," he said.

Pumping stations on the present line are at 30-mile intervals; with the expansion of the line, these intervals will be raised to 60 miles, Younts said. Although this will reduce the present line's capacity from about 100,000 to 67,000 bbl a day, the extra motors, placed at 120-mile intervals on the new line, will provide that line with a 100,000-bbl-per-day capacity.

Should the future need arise, a few additional pumping stations on the new line, which would result in 60-mile intervals, would raise the entire system's capacity to a grand total of 221,000 bbl a day.

"In other words," the executive explained, "the pipe line originally could carry the equivalent of 400 tank cars per day; in the near future, it will carry the equivalent of nearly 750 tank cars per day; and, should the need arise, it will be equal to over 1000 tank cars."

Younts reported that work on the new line began late in 1950 and will be completed the latter part of 1951. The expansion program will cost an estimated $52,000,000.

Plantation Pipe Line Company is owned jointly by Standard Oil Company (New Jersey), Standard Oil Company (Kentucky), and Shell Oil Company.

Canada Senate Studies 2200-Mile Pipe Line

Second reading has been given in the Canadian Senate to a bill for incorporation of a new pipe line that would transport crude oil from the Drumheller fields in the Province of Canada, to cities as far east as Montreal. Explaining the measure for incorporation of Trans-Canada Pipe Lines Company, Ltd., Sen. Paul Bouffard said the company plans a 2,200-mile pipe line eastward to serve the main cities on the Canadian Pacific and Canadian National Railway lines. These would include Toronto, Ottawa and Hull, as well as Montreal. The cost would be "at least $250,000,000."

The proposed pipe line would have a capacity of 365,000,000 cu ft of oil a day, which could be increased to a maximum of 500,000,000 and the oil would be sold through established distributing agencies in the various cities. Thus there would be no question of competition with established distributors, it was pointed out.

Senator Norman Lambert asked if it is expected that the Alberta Natural Gas Conservation Board will relax its present ban on export of oil and gas from that province. Senator Bouffard said he understood export had been postponed until next September when the supply situation will be surveyed.

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PIPELINE PERSONALS

F. T. Bailey has been made compressor superintendent of the Jal division by El Paso Natural Gas Company. Previously he was superintendent of the Eunice plant.

H. L. Poage, formerly chief operator of the Wasson plant, has been promoted to superintendent of Jal Plant No. 1.

L. G. Sweatt has been named superintendent of the Eunice plant.

T. J. Crutchfield is now assistant compressor superintendent of the Jal division.

H. R. Murray, who has been chief maintenance mechanic of Jal Plant No. 1, is now assistant superintendent in charge of the Monument plant.

Wilbur Hayse has been transferred to Jal Plant No. 3 as assistant plant superintendent. He has been chief maintenance mechanic at Jal Plant No. 2.

H. A. Boyd has been advanced to district foreman in the Jal maintenance department.

J. C. Williams, who has been chief maintenance mechanic at Eunice, has been appointed assistant superintendent of Jal Plant No. 2.

Paul R. Beebe, assistant superintendent of Jal Plant No. 3, has been promoted to chief operator of the Wasson plant.

J. C. Yoakum, formerly assistant superintendent of the Monument plant, has been transferred to the Dimmitt plant and made chief operator.

L. E. McElrath, Jr., formerly assistant superintendent at Jal Plant No. 2, has been advanced to chief operator at the Keystone plant.

R. C. Kiker has been promoted to district foreman in the Jal field maintenance department. He has been subforeman.

W. A. Disheroon, formerly superintendent of Lone Star Gas Company's Benjamin compressor station, has been made superintendent of the company's new station at Snyder, Texas. He has been succeeded at Benjamin station by **P. J. Hurd,** former Waco compressor station superintendent.

Dean DeGraffenreid, representative of Byron Jackson Company in Tulsa, Oklahoma, has become a member of The Pipe Liners Club of Tulsa. Other new members are **O. C. Gatrell,** Gulf Refining Company, Tulsa, and **J. W. Boyd,** Phillips Petroleum Company, Bartlesville, Oklahoma.

R. L. Reichard has been promoted to general superintendent of pipe lines by the Tulsa Pipe Line Division of the Gulf Refining Company.

J. D. Jones has been made assistant general superintendent, and **J. S. Hale** chief clerk of the Tulsa office.

James T. Lewis, Jr., former pipe line foreman of Panhandle Eastern Pipe Line Company's District 8 at Pittsfield, Illinois, has been made foreman of District 10 at Tuscola, Illinois. He succeeds **J. W. Roberts,** who is now with Trunkline Gas Supply Company in Houston, Texas. Lewis went to work for Panhandle Eastern March 25, 1931, at Lamont, Missouri. He has been foreman at Pittsfield since November 18, 1946.

John Kelly, assistant manager of Continental Oil Company's motor transportation division, Ponca City, Oklahoma, has been promoted to administrative assistant to **W. L. Kygar,** president of Continental Pipe Line Company, it is announced by George W. Evans, Houston, chairman of the board, Continental Pipe Line Company.

It was announced simultaneously that **Elmo P. Hester,** Houston, regional contract superintendent in the southern region of Continental Oil Company's motor transportation division, has been promoted to succeed Kelly as assistant manager of the division.

Kelly will continue to make his headquarters in Ponca City, where offices of Continental Pipe Line Company are located. Hester will move from Houston to Ponca City in his new assignment.

P. D. Phillips

F. O. Stivers

K. Eugene Graff

P. D. Phillips, Jr., has been appointed chief engineer by the Humble Pipe Line Company to succeed the late C. H. Lundt, and has named **F. O. Stivers** assistant chief engineer.

Phillips was graduated from Texas A. & M. College in 1934 with a BS degree in mechanical engineering. He began work with the company as a pipe-liner at Longview during the same year. He later worked in the East Texas division engineering office, at McCamey, and at Midland in engineering capacities. After returning from army service in World War II, he transferred to Houston where he served in engineering posts.

Stivers received a BS degree in mechanical engineering from Purdue University in 1940. Before going to work for Humble Pipe Line Company in April, 1945, he was with the Southeastern Pipe Line Company and the Plantation Pipe Line Company. His service with Humble has all been spent in the Houston office. Prior to his appointment as assistant chief engineer, he was senior mechanical engineer. Stivers is vice president of Houston Pipeliners Club.

K. Eugene Graff, formerly of Houston, Texas, has been named industrial engineer for Commonwealth Natural Gas Corporation, Richmond, Virginia, announces Erick Larson, president.

Graff formerly served as a project engineer for Fish Constructors, Inc., and Fish Engineering Corporation on the Transcontinental Gas Pipe Line Corporation project.

Since 1926, practically all of Graff's work has had to do with the utilization of natural gas, and more specifically with industrial application and use. In 1931 he joined the Northern Natural Gas Company, where for five years he served as industrial engineer. He became associated with the Webster Engineering Company in the capacity of combustion engineer in 1936 and traveled throughout the Continental United States as a specialist in industrial gas and oil installations.

Graff attended Purdue University and is a member of the Mid-West Gas Association and the American Society of Military Engineers. He served three years as a lieutenant in U. S. Navy Construction Battalions.

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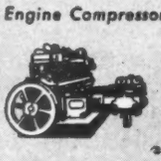

PIPE LINE PROJECTS

Phillips Contracts 278-Mile Line

Contract for construction of a 278-mile, 10-in. crude oil trunk line, extending east from Phillips, Texas, to Yale, Oklahoma, was awarded jointly to Brown Lite Company of Tulsa, Oklahoma, and Arey-Phillips Construction Company of Pampa, Texas, according to an announcement by K. S. Adams, president of Phillips Petroleum Company.

This line, to be owned and operated by a Phillips subsidiary, Phillips Pipe Line Company, will tie in the company's present West Texas-to-Borger crude oil line with the Oklahoma-Kansas crude systems. With an initial capacity of 25,000 bbl per day, the line will provide an outlet for Phillips large West Texas crude oil reserves and will aid in supplying the requirements of company refineries at Okmulgee, Oklahoma, and Kansas City, Kansas.

Completion date is set for June 1.

Cities Service Outlines Construction Plans

Cities Service Gas Company, of Oklahoma City, Oklahoma, has filed two applications with the Federal Power Commission in connection with the proposed construction of certain pipe line facilities, and the abandonment of others, in Kansas, Oklahoma, and Missouri.

In one of the applications (G-1589), Cities Service is seeking authority to install, at an estimated cost of $4,204,000, a total of 13,080 hp at new and existing compressor stations on its system.

The company would (1) install three additional 1600-hp units at its existing Hugoton station in Grant County, Kansas; (2) build a new 6400-hp station near Greensburg, Kansas; (3) construct a 1200-hp station near Welch, Oklahoma; and (4) build a 680-hp station near Pierce City, Missouri.

Cities Service said that the additional three units at the Hugoton station will increase its system's daily capacity to 323,000,000 cu ft, or an increase of 55,500,000 cu ft. The new 6400-hp station near Greensburg would enable the company to utilize this additional capacity on its Hugoton-Kansas City line. The proposed new stations near Welch and Pierce City would increase capacity of the company's Quapaw (Oklahoma)-Springfield (Missouri) line.

In the other application (G-1590), Cities Service is proposing to lay approximately 56 miles of 16, 10, and 3-in. pipe in Sedgwick, Harvey, and Labette counties, Kansas. The facilities, estimated to cost about $982,610 would provide increased capacity in the Wichita-Newton, Kansas, area and in the Parsons, Kansas, area.

The facilities that Cities Service plans to abandon consist of approximately 192 miles of line, ranging from 2 to 12 in. in diam, in Reno, Sedgwick, Wilson, Harvey, Kingman, and Labette counties, Kansas. The company said that on most of the sections of line to be abandoned, maintenance and leakage have become excessive, and operation of the old lines is no longer necessary. Cities Service also said that virtually all of the facilities sought to be abandoned are urgently needed for construction, because of the present shortages of pipe and the almost certain prospect that these shortages will become progressively more acute.

Lake Shore Authorized to Serve Northeast Ohio

The Federal Power Commission has issued an opinion and order authorizing Lake Shore Pipe Line Company, of Cleveland, Ohio, to acquire, construct, and operate pipe line facilities that will carry natural gas into the northeastern Ohio area for the first time.

The commission concurrently denied the applications of Erie Gas Service Company, Inc., of Oil City, Pennsylvania, and Grand River Gas Transmission Company, of Cleveland.

Lake Shore's project, estimated to cost about $1,450,000, will include approximately 45 miles of 10¾-in. line extending northwest from a point of interconnection with Tennessee Gas Transmission Company's system near Meadville, Pennsylvania, to Ashtabula, Ohio, where it will connect with 27 miles of 10¾-in. line extending west from Ashtabula to Fairport. The 27-mile section is to be acquired from The Lake Shore Gas Company.

Montana-Dakota Plans Include Construction

Montana-Dakota Utilities Company, of Minneapolis, Minnesota, has applied to the Federal Power Commission for authority to acquire natural gas facilities of three companies operating in Montana and Wyoming, to construct interconnections between the properties proposed to be acquired, and to build additional compressor facilities.

Montana-Dakota proposes to acquire all operating properties and the Elk Basin Cloverly Gas Reservoir of the Billings (Montana) Gas Company; to purchase that portion of the operating properties of The Rocky Mountain Gas Company, of Casper, Wyoming, which serves the Cowley, Lovell, Powell, and Byron, Wyoming, area, and to purchase all capital stock of Big Horn Gas Company, of Basin, Wyoming.

The facilities to be purchased from Billings include a desulfurization and dehydration plant, a compressor station, and an 88-mile pipe line. Billings Gas Company serves Billings, Laurel, Park City, Silesia, Joliet, Edgar, Fromberg, Bridger, and Belfry, Montana.

The Rocky Mountain Gas Company properties include 41 miles of line supplying gas at retail in Cowley, Lovell and Powell, the distribution systems is those three communities, and a spur line extending from the Garland gas field to Lovell. The Big Horn properties consist principally of a line extending from the Little Buffalo Basin field in Hot Springs Coun- Wyoming.

Montana-Dakota plans to interconnect these facilities with the pipe line owned by Montana-Wyoming Gas Pipe Line Company and operated by Montana-Dakota. In addition, two 880-hp compressor units and other necessary equipment would be added to the Worland compressor station. These facilities are to be built and owned by Montana-Wyoming and operated by Montana-Dakota under lease. Montana-Dakota would build a compressor station consisting of two 330-hp units together with dehydration facilities in the Little Buffalo Basin field.

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Ohio Fuel Would Operate Storage Pools

Ohio Fuel Gas Company, of Columbus, Ohio, has applied to the Federal Power Commission for authorization to construct pipe line facilities for the conversion of six natural gas producing pools in Ohio to storage pools. The pools have an ultimate storage capacity of about 35.7 billion cu ft, the application says.

To convert the pools to storage service, Ohio Fuel plans to construct about 74.2 miles of high pressure storage project pipe lines, and to remove about 53.2 miles of existing well and field lines. The company also proposes an increase of 10,780 hp in compression facilities for storage service, and to construct approximately 47.5 miles of 20-in. line to transport the gas to market areas.

Total estimated capital cost of the proposed construction is $6,425,200.

Three of the pools to be converted to storage service are located in Ashland County, two in Hocking County, and one in Knox County. The 47.5-mile line will extend from Benton Township in Hocking County to Columbus.

Ohio Fuel said it hopes to commence the construction program early in 1951, with the entire project to be completed by November 1, 1952.

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A $32,000,000 Utah Gas Line Proposed

The Utah Natural Gas Company has asked the Utah Public Service Commission to issue a conditional certificate of necessity for construction of a $32,000,000 pipe line. The proposed line would transport natural gas from southeastern Utah to Salt Lake Valley. Previously the company had asked only for permission to construct the line.

Great Lakes to Construct Des Moines-Iowa City Line

Increased capacity to Great Lakes Pipe Line Company terminals at Iowa City and Chicago will be provided by construction of an 8-in. line from Des Moines to Iowa City, Iowa, Harry Moreland, Great Lakes president, has announced. The line will be built this spring and will parallel an existing 6-in. line. The 6-in. was laid in 1930 as part of the original system of the pipe line company.

Added line capacity to Iowa City will make it possible to abandon secondary stations between there and Des Moines and also will make available an increased barrelage of products for movement to Chicago. To pump this additional volume, existing stations at Prophetstown and Lee, Illinois, will be returned to use, placing the 6-in. on 50-mile operation from Des Moines to Chicago. The 8-in. line will be pumped from Des Moines to Iowa City.

Construction also will include erection of tankage at both terminals, modernization of transport loading facilities at Iowa City where an office building, with a laboratory in conjunction, also will be built.

Michigan Gas Storage Will Need More Lines

Michigan Gas Storage Company, of Jackson, Michigan, has asked the Federal Power Commission for authority to acquire and construct new facilities in Michigan required to handle an additional gas supply that the company expects to receive next winter from Panhandle Eastern Pipe Line Company.

Michigan Gas is proposing to acquire the Riverside gas field, in Missaukee County, Michigan, for development as a natural gas storage area. In connection with the field, the company would acquire an existing line and facilities owned by Consumers Power Company.

The proposed construction includes approximately 78 miles of 24, 22, and 16-in. line extending from Laingsburg Junction to a point near Pontiac-Mt. Clemens, together with three lateral lines into Consumers' southeast division, in the Pontiac area and an additional 7400-hp compressor capacity at the Muskegon River compressor station. The company also would build about 30 miles of 26-in. line looping its existing Muskegon River-Freedom Junction line, and necessary metering and regulating stations.

Estimated overall capital cost of the acquisition and construction is $10,866,000.

Gas Storage Utilization Will Require Pipe Lines

New York State Natural Gas Corporation, of New York City, has asked the Federal Power Commission to authorize it to acquire the South Bend storage area in Armstrong and Indiana counties, Pennsylvania, and to construct facilities necessary to utilize the area for the underground storage of natural gas.

The South Bend pool is expected to have a storage capacity of 13 billion cu ft of gas, with deliverability of 100,000,000 cu ft or more per day. New York State Natural proposes to acquire the properties from The Peoples Natural Gas Company, of Pittsburgh, Pennsylvania. The additional gas that would be made available through operation of the pool would be delivered to Peoples and The East Ohio Gas Company, of Cleveland, Ohio, both of which are affiliates of New York State Natural in the Consolidated Natural Gas system.

The application says that in order to inject and withdraw gas from the South Bend pool and make delivery to Peoples and East Ohio, a 77-mile, 20-in. transmission line would be built between the storage area and a point on the Ohio-Pennsylvania State Line in Lawrence County, Pennsylvania.

New York State Natural also plans to build a total of approximately 17 miles of field lines and a 12,000-hp compressor station in the storage area.

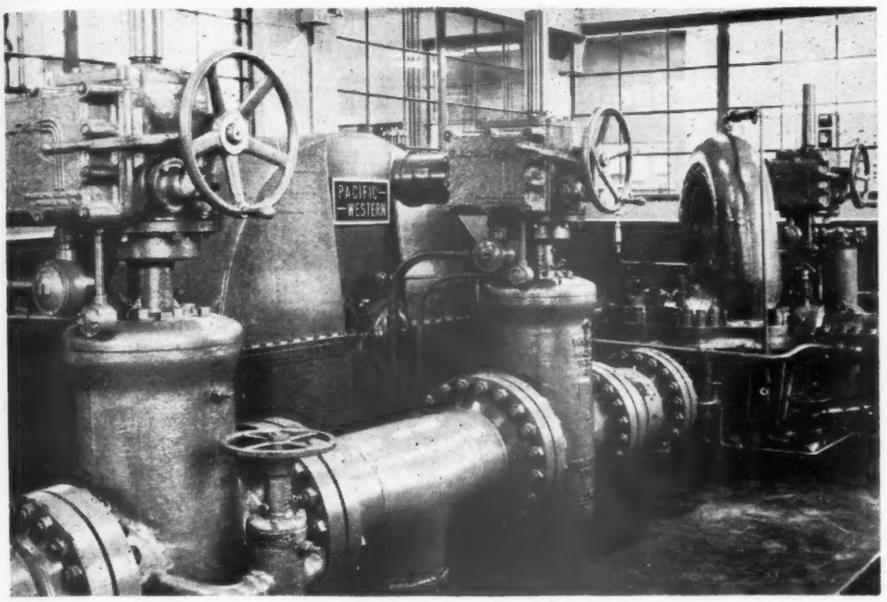
Total estimated capital cost of the project is $8,969,100.

Facilities to Connect Storage Field Proposed

Texas Gas Transmission Corporation, Owensboro, Kentucky, has asked the Federal Power Commission for authority to construct the necessary natural gas facilities to connect and operate the Alford underground storage field, near Petersburg, Indiana. Estimated cost of the project is $938,811.

Texas Gas proposes to build a 12-mile connecting line, a 1200-hp storage field compressor station, a storage gas measuring station, and 4.5 miles of storage field gathering lines.

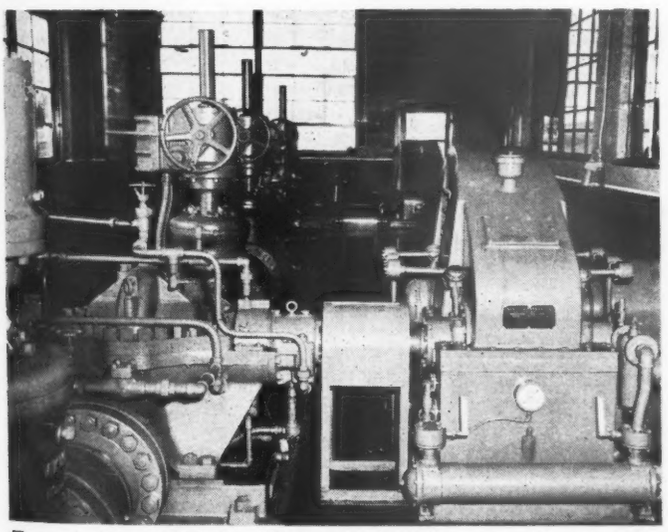
WESTERN GEAR DESIGNS, BUILDS LARGEST U. S. PIPELINE SPEED INCREASERS



Two of these 1700-horsepower Pacific-Western high-speed units installed at the Clarkson, Kentucky station of the Mid-Valley pipeline transmit power for pumping current requirements of 157,000 barrels of crude oil per day.

1000-Mile Mid-Valley Pipeline Uses Eight Western-Built High-Speed Units

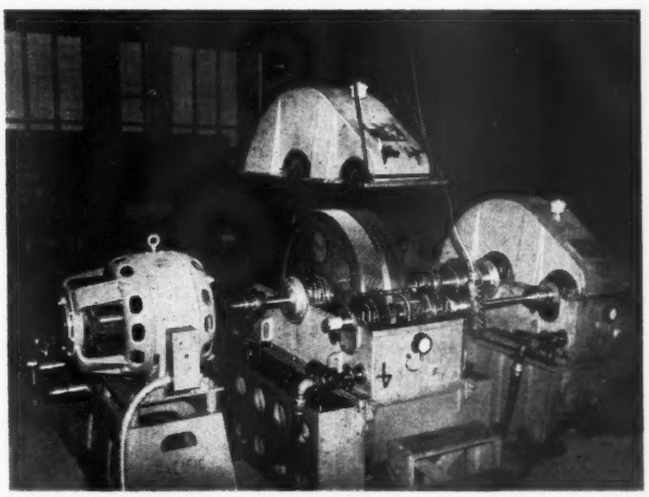
Four high-speed units of 1700 horsepower and four of 1200 horsepower are operating in pumping stations of the 1,000-mile Mid-Valley pipeline. All eight units were designed and manufactured in the Lynwood, California, plant of Western Gear Works. The 1700-horsepower speed increasers are the largest ever built for pipeline service in the United States.



Two of these 1200-hp high-speed units operating in the Haynesville, Louisiana, pumping station, transmit power for the delivery of current requirements of 108,000 barrels per day.

Numerous problems involved

The manufacture of gear units of this type involves many problems of design, lubrication, production, and testing. Particular emphasis was placed on sound levels, and these gears are exceptionally quiet in operation under full-load, full-speed conditions. The entire project of design and manufacture to the required specifications was one that called for many years of gear-making experience, and was logically assigned to a company with a background of more than fifty years in the business.



1200-hp Pacific-Western high-speed unit on test stand with cover removed. Gear requirements for the Mid-Valley pipeline are (1) transmitting 1200 hp at 453 rpm from a Diesel engine with step-up in ratio of 1:8 to a 3600-rpm centrifugal pump; and (2) transmitting 1700 hp at 329 rpm stepped up in a ratio of 1:11 to a 3600-rpm pump. The increases in speed are made in one stage, even for the extreme 1:11 requirement, and pitch-line velocities are as high as 7370 fpm.

5022

For help on gear problems of any type, write or call your nearest Pacific-Western plant or office

Plants: Box 192, Lynwood (Los Angeles County), California
417 Ninth Ave. S., Seattle 4, Washington
1035 Folsom St., San Francisco 3, California
117 N. Palmer, Houston 3, Texas

Representatives: 930 So. E. Oak St., Portland 14, Oregon
Room 211, Chamber of Commerce Building, Denver 2, Colorado

WESTERN GEAR WORKS

Manufacturers of **PACIFIC-WESTERN** Gear Products

Pacific Gear & Tool Works

Plants at:
Seattle
San Francisco
Lynwood
(Los Angeles County)
Houston
Representatives:
Portland
Denver

With the PIPE LINE CONTRACTORS

Latex Construction Company of Georgia, Atlanta, Georgia, has been awarded a contract by Plantation Pipe Line Company amounting to approximately $1,500,000 for construction of stations and terminals required in the company's $52,000,000 expansion program. Pump station buildings will be enlarged at Baton Rouge, Louisiana; Collins, Mississippi; Akron and Silver Run, Alabama; Bremen and Center, Georgia; and Spartanburg, South Carolina. Existing terminals will be enlarged at all main line points between Baton Rouge and Charlotte, North Carolina.

Anderson Brothers Construction Company, 707 Drennan Street, Houston, Texas, is at work on a total of 297 miles of pipe line for the Trunkline Gas Supply Company. One section, 217 miles of 24 in., is between Longville, Louisiana, and Garwood, Texas. The other section is 180 miles of 26-in. between Darnell, Louisiana, and Senatobia, Mississippi. For this same company, two crossings are being made of the Trinity River and one of the Calcasieu.

After being shut down for some time due to winter weather, work is now going ahead on the 57 miles of 8-in. for Miami Valley Corporation between Cincinnati and Dayton, Ohio.

Houston Contracting Company, 3272 Westheimer Road, Houston, Texas, is working on the following contracts:

For Trunkline Gas Supply Company, 176 miles of 26-in. between Longville and Darnell, Louisiana.

For Tennessee Gas Transmission Company, 25 miles of 12-in. from Grand Cheniere, Louisiana, to a point near Rollover Lake.

H. C. Price Company, Pipeline Division, P.O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of approximately 480 miles of high pressure natural gas pipe line for Texas Illinois Natural Gas Pipeline Company from near Refugio, Texas, northeastward to the Texas-Arkansas state line near Texarkana. Work on 36 miles of 24-in. extension to Old Ocean field from near Hungerford is completed; work on 110 miles of the main 30-in. pipe line from Hungerford to the Trinity River completed; work on 38 miles of 12-in. from Old Oceans field to Chocolate Bayou field completed; work on 97 miles of 26-in. from Hungerford to near Refugio, Texas completed. Right-of-way work on the additional 200 miles of 30-in. from the Trinity River to Texarkana is now underway. Spreads are located as follows:

Carthage, Texas: W. B. Williams, superintendent; P. O. Rutledge, office manager; R. H. Edwards, and D. L. Beachy, right-of-way foremen; K. K. Kelly, ditch; Roy Stegall, bending; J. I. Cobb, pipe; C. F. Jones, welding; Rube Owens, coating; A. D. Hamilton, lower in, and Fred Williams, clean-up.

Nacogdoches, Texas: C. R. Ice, superintendent; G. A. Harvey, office manager; John E. Hamilton and Jessie Cash, right-of-way foremen; E. W. Whisenant, ditch; Forest Loinette, bending; W. T. Dickerson, pipe; L. O. Reutzel, welding; N. D. Adams, coating; J. C. Rich, lower-in; E. D. Worley, clean-up.

Rumsey Brothers Pipe Line Construction Company, M. and M. Building, Houston, Texas, will construct approximately 100 miles of Platte Pipe Line Company's system, which overall extends from Wyoming to the St. Louis-Wood River area. The 100-mile section will be from the Nebraska-Kansas state line near Lanham, Kansas, to the Missouri River near Doniphan, Kansas. Work will begin as soon as pipe is delivered. Joe Al Works will be superintendent and Walter A. Hale manager of the field office. The line will be laid of 16 and 20.-in. pipe.

Western Pipe Line Coating Company, Inc., P. O. Box 1063, Wichita Falls, Texas, is coating 135 miles of 10-in. pipe for Brown Lite Company of Tulsa. The pipe will be laid for Phillips Petroleum Company between Yale and Clinton, Oklahoma. Cecil D. Carey is general superintendent for Western Pipe Coating. For the Martin Construction Company of Ulysses, Kansas, 40 miles of 8-in. are being coated that will go into a transmission system to the City of Trinidad, Colorado. C. M. Vaughn is superintendent. For Warner Brothers of Denver, Colorado, 37 miles of ¾-in. through 8-in. are being coated that will compose a distribution system in the City of Trinidad. H. W. Carey is superintendent.

Oklahoma Contracting Company, 1210 Mercantile Bank Building, Dallas, Texas, has contracted two jobs, totaling 240 miles.

Near Falfurrias and Victoria, Texas, 65 miles of 26 and 30-in. loops will be laid for Tennessee Gas Transmission Company. Headquarters will be at Falfurrias with Panama Shifflet superintendent in charge. This work is scheduled to begin about May 1.

From the Hudson River just south of Albany, New York, to a point near Wilmington, Massachusetts, 175 miles of 24-in. will be laid for Tennessee and its subsidiary, Northeastern Gas Transmission Company. Three spreads will be used on this job. H. A. "Red" Wylie will have one gang, with headquarters at Pittsfield, Massachusetts. Aldress Kilgore and his gang will make headquarters at Westfield, Massachusetts. L. B. Rea will have the third spread, but his headquarters are not yet determined. Right-of-way and ditching operations will begin about April 1 and pipe work May 1. Headquarters for the entire job will be in Springfield, Massachusetts, with Paul R. Halbert in charge. Harry Prindle will be his assistant.

Arabian Bechtel Corporation, 220 Bush Street, San Francisco, California, is at work on the 566-mile pipe line for Iraq Petroleum Company, from the Kirkuk field in northern Iraq to Banias on the Mediterranean seaboard. Clark Rankin, vice president, is project manager.

Associated Pipe Line Contractors, Inc., P.O. Box 2163, Houston, Texas, has under construction 121 miles of 16-in. for Southern Natural Gas Company. The line is from Tuskegee, Alabama, to Macon, Georgia. Lacy Walker is superintendent and Buck Johnson manager of the field office, which presently is at Columbus, Georgia.

Bishop and Lock, 503 Magnolia Building, Dallas, Texas, has been awarded a contract to lay that part of Platte Pipe Line Company's system between Marysville, Kansas, and Holdrege, Nebraska, a distance of 142 miles. Due to delay in pipe delivery, the work is not expected to get under way until sometime in May. This is part of Platte's crude oil line from Wyoming to the St. Louis-Wood River area.

Parkhill Truck Company, P.O. Box 1856, Tulsa, Oklahoma, is stringing 217 miles of 24-in. for Anderson Brothers Construction Company on Trunkline Gas Supply Company job from Longville, Louisiana to Garwood, Texas.

Other jobs are: For Houston Contracting Company, 176 miles of 26-in. on Trunkline between Longville and Darnell, Louisiana. Foremen are F. L. Bridges and O. C. McCoy.

For Midwestern Constructors Inc., on Texas Illinois Natural Gas Pipeline 100 miles of 26-in. from La Gloria to Refugio, Texas. Harold Deatherage is foreman.

Sections 7, 8, 9, and 10 on the Texas Illinois for Bechtel Corporation, 417 miles of 30-in. from Texarkana, Arkansas, to the Mississippi River near Cape Girardeau, Missouri. Foremen: Charles Sampson on Section 9; Jimmie Stubblefield 7.

Sections 11, 12, and 13 on the Texas Illinois job, for Midwestern Construction, Inc., 300 miles of 30-in. from the Mississippi River near Cape Girardeau to Joliet, Illinois. Curtis Williams is foreman.

For Anderson Brothers on Trunkline system, 180 miles of 26-in. from Darnell, Louisiana to Senatobia, Mississippi. The foreman is Ira Gould.

H. L. Gentry Construction Company, 921 Michigan Avenue, Jackson, Michigan, has under construction 55 miles of 12 ¾-in. pipe line for the Southeastern Michigan Gas Company between Birmingham and Port Huron, Michigan. The field office is at Utica; telephone 75122. Frank Morris is superintendent and Joe Malloy office manager.

O. R. Burden Construction Company, P.O. Box 5216, Tulsa, Oklahoma, expects to begin work in May on the Platte Pipe Line Company job. This contractor recently was awarded a contract to lay 280 miles of the system, that section between the Missouri River near St. Joseph, Missouri, and the Mississippi River, near Wood River, Illinois.

For The Texas Pipe Line Company, 56.6 miles of 10 ¾-in. pipe is being laid from Lawrenceville, Illinois, to Mount Vernon, Indiana. The new line is paralleling the company's existing 6-in. line. The field office is at Mount Carmel, Illinois. Pete Hiner is spread superintendent. Hiner also is supervising the laying of 32 miles of 8-in. for the Union Gas and Electric Company. The field office is at Bloomington, Illinois.

The contractor is doing considerable take-up work in Texas; for Service Pipe Line Company, 183 miles of 8-in. and 40 miles of 6-in. The lines are between Dallas and Fort Worth, Fort Worth and Chico, and Ranger and Fort Worth. Between Sherman and Armstrong, Texas, 52 miles of 6-in. are being taken up for The Texas Pipe Line Company.

R. H. Fulton and Company, P.O. Box 1526, Lubbock, Texas, will lay Platte Pipe Line Company's line from Chatham station in Wyoming to Brule, Nebraska, approximately half of the 1072-mile system. This contract was recently awarded and work has not yet begun.

Fulton also has contracted to lay 56 miles of 12 ¾-in. crude oil line for The Texas Pipe Line Company between the Chico station in Wise County, Texas, and Wichita Falls. The field office is at Henrietta, where M. L. Boyd is superintendent and C. E. Helwig office manager.

Bad weather has delayed work on Trunkline Gas Supply Company's system, the 184-mile section of 26-in. from Senatobia, Mississippi, to Joppa, Illinois. The field office is at Memphis, Tennessee. Ed Veach is spread superintendent and Bill Gray office manager. Clark Williams is general superintendent.

For Northern Natural Gas Company, 155 miles of 20-in. is being laid between Jetmore and Bushton, Kansas, and 73 miles of 26-in. from Concordia to Salina, Kansas. Jerry Nash is in charge of the former job and M. L. Boyd of the latter.

As a joint venture, R. H. Fulton and J. T. Brodie are laying 264 miles of 20-in. for Trunkline Gas Supply Company between McAllen and Altair, Texas. The field office is at Victoria. J. T. Brodie is in charge. Bill Fenn is spreadman.

Williams Brothers Corporation, National Bank of Tulsa Building, Tulsa, Oklahoma, is at work on 707 miles of 14 and 18-in. pipe line for the Plantation Pipe Line Company, paralleling its system between Baton Rouge, Louisiana, and Charlotte, North Carolina. The 432 miles from Baton Rouge to Bremen, Georgia, is being laid of 18-in. pipe, and the 275-mile section from Bremen to Charlotte of 14-in. Two spreads are operating. One is making its headquarters at Talladega, Alabama, with T. Davis superintendent and J. E. G. Jester office manager. The other spread is at Tuscaloosa, Alabama, with Whitey Martin superintendent and R. G. Conley office manager. O. R. Mitchell is in charge of a crossing of the Tombigbee River near Livingston, Alabama.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa, Oklahoma, has contracted to install station additions and piping for Panhandle Eastern Pipe Line Company at Tuscola, Illinois, Zionsville, Indiana, and Edgerton, Indiana. The work is scheduled to begin March 1.

Schedule 1 for Texas Illinois Natural Gas Pipeline Company, 100 miles of 26-in. between La Gloria and Refugio, Texas, has been completed.

Schedule 11, 100 miles of 30-in. from the Mississippi River near Chester, Illinois, to Effingham, was 28 per cent completed when shut down for the winter. The field office is at DuQuoin, Illinois. M. T. Wilhite is superintendent and John Work spreadman.

Schedule 12, 100 miles of 30-in. from Effingham to Sibley, Illinois, and Schedule 13, 92 miles of 30-in. from Sibley to Joliet, Illinois, will get underway in the spring.

The crossing of the Illinois River near Morris was approximately 80 per cent completed February 12. Clyde Peters is superintendent and Bill Daniels office manager. Field headquarters are at Morris.

H. C. Price Company, Somastic Division, Bartlesville, Oklahoma, has the following work in progress:

Philadelphia plant operations:

Okonite-Callender Cable Company, Inc. — Application of Somastic coating and internal cleaning and coating to 31,150 ft of 6⅝ in. OD pipe; 25,720 ft of $5\frac{9}{16}$-in. OD pipe; 1850 ft of 6⅜-in. OD pipe.

Phelps-Dodge Corporation—Application of coating and internal cleaning and coating to 55,500 ft of $5\frac{9}{16}$-in. OD pipe.

Susquehanna Pipe Line Company —Application of coating to 5000 ft of 6⅝-in. OD pipe.

Philadelphia Electric Company—Application of coating to 64,750 ft of 16-in. OD pipe; 1000 ft of 20-in. OD pipe.

Philadelphia Gas Works Company —Application of coating to all pipe requirements for 1951 from 1¼-in. to 30-in.

New Orleans plant operations:

United Gas Pipe Line Company—Application of Somastic coating to approximately 66,000 ft of 6⅝-in. OD pipe; 42,000 ft of 8⅝-in. OD pipe; 35,500 ft of 10¾-in. OD, 0.307-in. wall pipe; 52,800 ft of 12¾-in OD pipe; 47,500 ft of 16-in. OD ¼-in. wall pipe; 322,000 ft of 16-in. OD, 5/16-in. wall pipe; 14,500 ft of 16-in. OD, ½-in. wall pipe; Somastic and Hevicote to 15,000 ft of 16-in. OD, ¼-in. wall pipe.

▸ **Dunn Brothers.,** 801 Mercantile Securities Building, Dallas, Texas, are stringing pipe for H. C. Price Company on the Texas Illinois Natural Gas Pipeline Company project, as follows:

Section 4—109 miles of 30-in. from Glenflora to Urbana, Texas.

Section 5—91 miles of 30-in. from Urbana to Dotson, Texas.

Section 6—99 miles of 30-in. from Dotson to the Texas-Arkansas state line.

Other jobs being strung by the company are as follows:

El Paso Natural Gas Company—415 miles of 24-in. between Fruitland, New Mexico, and Yucca, Arizona. (San Juan line).

El Paso Natural Gas Company—419 miles of 30-in. in New Mexico, Texas, and Arizona.

▸ **Brown Lite Company,** Tulsa, Oklahoma, and **Arey-Phillips Construction Company,** Pampa, Texas jointly will lay a 278-mile, 10-in. crude oil line for the Phillips Pipe Line Company. The line will be between Phillips, Texas, and Yale, Oklahoma. Construction is to begin immediately, with the completion date set for June 1.

▸ **Vaughn and Taylor Construction Company, Inc.,** P.O. Box 1351, Wichita Falls, Texas, began work February 10 on a 165-mile gathering system in Sherman County, Texas, for Phillips Petroleum Company. The pipe size is 3 in. through 12 in.

The middle of the month the gathering system being laid for Sunray Oil Corporation was about 80 per cent completed. This consisted of 138 miles of 3 in. through 30 in. at Snyder, Texas.

At Burkburnett, Texas, 35 miles of 3-in. through 10-in. pipe is being taken up for the South Texas Pipe and Supply Company, the work being about 60 per cent completed.

The contractor during February completed installing a crossing of the Brazos River near Mineral Wells, for Service Pipe Line Company. It was an 8-in. line.

▸ **Tulsa Construction Company,** 114 East Fifth Street, Tulsa, Oklahoma, is laying 40 miles of 12-in. line for Mid-South Gas Company, between Helena and Forrest City, Arkansas. Frank McCoy is superintendent and Bill Robinson manager of the field office.

▸ **Western Pipeline Constructors, Inc.,** Austin, Texas, is laying 97 miles of 26-in. and 38 miles of 12-in. on the Texas Illinois Natural Gas Pipeline Company system.

▸ **Bechtel Corporation,** 220 Bush Street, San Francisco, California, is working three spreads on the Texas Illinois Natural Gas Pipeline Company job, consisting of 409 miles of 30-in. in Arkansas and Missouri. The project office is at 409 East Markham Street, Little Rock, Arkansas. E. W. Davis is division manager, E. J. Hayes division office manager, and E. C. Elting project office manager. One spread is working from Newport, Arkansas, with J. E. Richardson superintendent, another from Texarkana, Arkansas, with V. L. Williams superintendent, and the third from Poplar Bluffs, Missouri, with A. M. Berlander superintendent.

▸ **Conyes Construction Company,** 2884 San Pablo Avenue, San Pablo, California, is laying approximately 180 miles of 20 and 22-in. crude oil line for Ohio Oil Company, extending from Carlos, Indiana, to Vandalia, Illinois. Jimmy Allman is superintendent.

▸ **Mahoney Contracting Company,** 1234 South Holmes Street, Lansing, Michigan, has been delayed in recent months on the Trunkline Gas Supply Company job due to bad weather. This company is laying 186 miles of 26-in. from Tuscola to Joppa, Illinois.

▸ **Texas-Louisiana Contractors,** 804 Dan Waggoner Building, Fort Worth, Texas, are laying 50 miles of 20-in. for United Gas Pipe Line Company to serve the Dow Chemical Company plant at Freeport, Texas. The line originates in the vicinity of Rosenberg. There are two spreads, one operating from 1805 Avenue H, Rosenberg, the other from Angleton.

▸ **Trojan Construction Company, Inc.,** 1416¼ North Robinson Street, Oklahoma City, Oklahoma, expects to complete about March 10 the 53 miles of 26-in. it is laying for Oklahoma Natural Gas Company between Edmond and Depew, Oklahoma. The field office has been moved from Stroud to Chandler. Charles T. Tillotson is superintendent and Vernon Yeager office manager. The above is a new street address.

▸ **Williams-Austin Company,** Grant Building, Pittsburgh, Pennsylvania, is working on 6½ miles of 20-in. for the New York State Natural Gas Corporation, beginning at the Tonkin station storage field in Westmoreland County, Pennsylvania, and extending eastward. The warehouse is at New Kensington. Ralph Gaddy is superintendent and E. E. Mayes timekeeper.

Beginning in March, the contractor's construction program calls for the operation of three spreads until November 1. Work will be done in the states of Pennsylvania and New York, location and personnel to be announced later. Officials of the company state they will need foremen, operators, and welders, and that anyone interested in a full season's work should contact Ed Peters at New Kensington, Pennsylvania, telephone 1738; or Brooksville, Kentucky, telephone 4626.

▸ **Delmer M. Spafford,** 823 West Main Street, Farmington, New Mexico, is laying gathering lines in the Blanco field for Southern Union Gas Company, size of pipe being 4 in. through 12 in. Spafford is personally in charge, with J. C. Smithee ditch foreman, Roy Scribner dope, and Bob Hall welding.

Work began in February on 10 miles of 12-in. for Southern Union on its Albuquerque main line. Delmer Spafford is general superintendent, C. Peters spread superintendent, and the following foremen: C. Mahan, ditch; L. Coy, pipe; J. Tafoya, dope, and C. Hicks, welding. After completion of the 10 miles, 5½ miles of 12-in. will be laid on the Kutz Canyon end of the Albuquerque main line.

More Personals

▸ **C. J. Jarrett** is now back on the job as maintenance foreman at Richland, Missouri, for Shell Pipe Line Corporation. He has been on loan to Portland-Montreal pipe line project.

▸ **Kirk H. Logan,** research engineer of the Cast Iron Pipe Research Association, Washington, D. C., has been designated to receive the 1951 Frank Newman Speller Award, and **H. H. Uhlig,** head of the Corrosion Laboratory, Massachusetts Institue of Technology, Cambridge, Massachusetts, to receive the 1951 Willis Rodney Whitney Award. The awards are given yearly by the National Association of Corrosion Engineers, Houston, Texas. The Speller Award is given for contributions to corrosion engineering and the Whitney Award for contributions to the science of corrosion.

Logan, long active in the National Bureau of Standards investigating underground corrosion currently is experimenting with methods to prevent corrosion. Dr. Uhlig is editor of the *Journal of the Electrochemical Society* and author of many published papers on corrosion. The awards will be presented officially at the annual banquet of the NACE at Hotel Statler, New York City during the association's seventh annual conference.

NEWS

IOCC Seeks Pact Renewal

Interstate Oil Compact Commission is seeking to renew its agreement at the present Congressional session. Chairman Allan Shivers, Texas governor, will ask the President and Congress to approve the agreement. The Commission, which was organized in 1935, works under a compact adopted by Congress and approved by the states. There are now 20 states as members.

Seek Unitization Repeal

Oklahoma is seeking repeal of a statute permitting unit operation of oil and gas fields in that state. The bill has been introduced to the legislature. Under terms of the law, a majority of the operators in a given field may appeal to the corporation commission for adoption of a program to operate the entire field as a single lease and under one management. Objective is to halt the waste of natural gas and thus insure a greater recovery of oil.

Producers to Supply Data

The State Department of Conservation of Louisiana has asked the state's crude oil and distillate producers to estimate how much more production would be practical from their properties. The department said the information is being sought by the Petroleum Administration for Defense. The data must include the location of such crude by field, type, and gravity.

Canada Steel Requirements Estimated at 100,000 Tons

Canada's oil industry requirements for steel are expected to be more than 100,000 tons, officials of Western Canada Petroleum Association announced. Early returns from operating companies indicate at least 2,608,000 ft of pipe will be required, and according to Association officials, many companies have not yet submitted 1951 estimated requirements. Development wells numbering 641 are now definitely slated for the year ahead and there may be more.

Need Depletion Allowance

John C. Robbins, Jr., head of the oil and gas committee of the Longview, Texas Chamber of Commerce has pointed out that 97 per cent of new oil discoveries are made by independents, and that the depletion allowance is vital to their operations. Robbins' statement was in answer to President Truman's recent opposition to the 27½ per cent allowance.

World Oil Demand Up

World oil demand is up about 10 per cent from last year with present consumption being nearly 11,000,000 bbl daily, Frank W. Abrams, chairman of the board of Standard Oil Company (New Jersey), reports. Attending a meeting of his company's coordination committee, in Caracas, Venezuela, Abrams predicted that Venezuela would lose some of its European market in 1952, after new refineries, which will use Mideast oil, are completed in England and the Low Countries. The 1951 demand is expected to increase still more due to greater industrial activity in the U. S., Europe, and Latin America.

Federal Gas Council

Formation of a federal gas council is expected to take place within the next few weeks. The council will be similar to the National Petroleum Council. Secretary of the Interior Oscar Chapman has informed the industry of his willingness to appoint a separate advisory council to represent the natural gas industry, and to name an assistant deputy administrator of gas in the Petroleum Administration for Defense. Gas officials are urging that the industry be given a set-up, separate from the oil agency, to handle problems of gas transmission and distribution.

Study Origin of Oil

An intensive study, to be conducted for the American Petroleum Institute's Research Committee by the University of California, will probe the role of marine sediments in creating crude oil. The remains of prehistoric marine animal and plant life buried in sedimentary rock strata generally are believed to be the source of oil formations, but no detailed scientific evidence exists as to how this conversion occurs. An understanding of the formation of oil would aid markedly in the location and development of new deposits.

An initial authorization of $20,000 to carry the project to the start of the next fiscal year in July, together with the first year's appropriation, has been approved by the Research Committee, which is headed by Dr. Robert E. Wilson, board chairman of Standard Oil Company (Indiana). The annual cost of the study will be approximately $123,000.

Mexico Oil Exports Highest Since 1930

Mexico's 1950 oil exports were the highest last year since 1930, the government oil administration reported. It said the exports last year were 24,000,000 bbl, compared to 26,000,000 bbl in 1930. During the last war, exports dropped to 4,000,000 bbl.

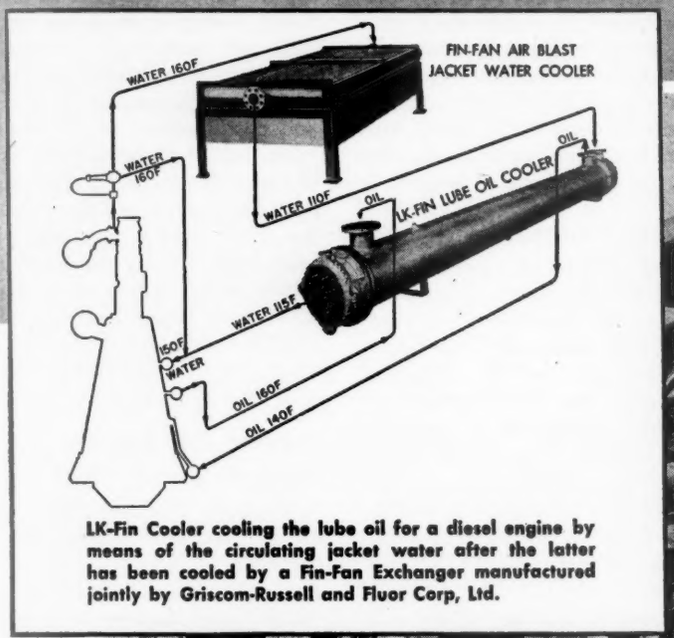
Mrs. Carpenter accepts the Distinguished Service Award for the late Charles B. Carpenter, her husband. The award from the Department of Interior is presented by Harry Fowler of the Bureau of Mines.

Government Bestows Award

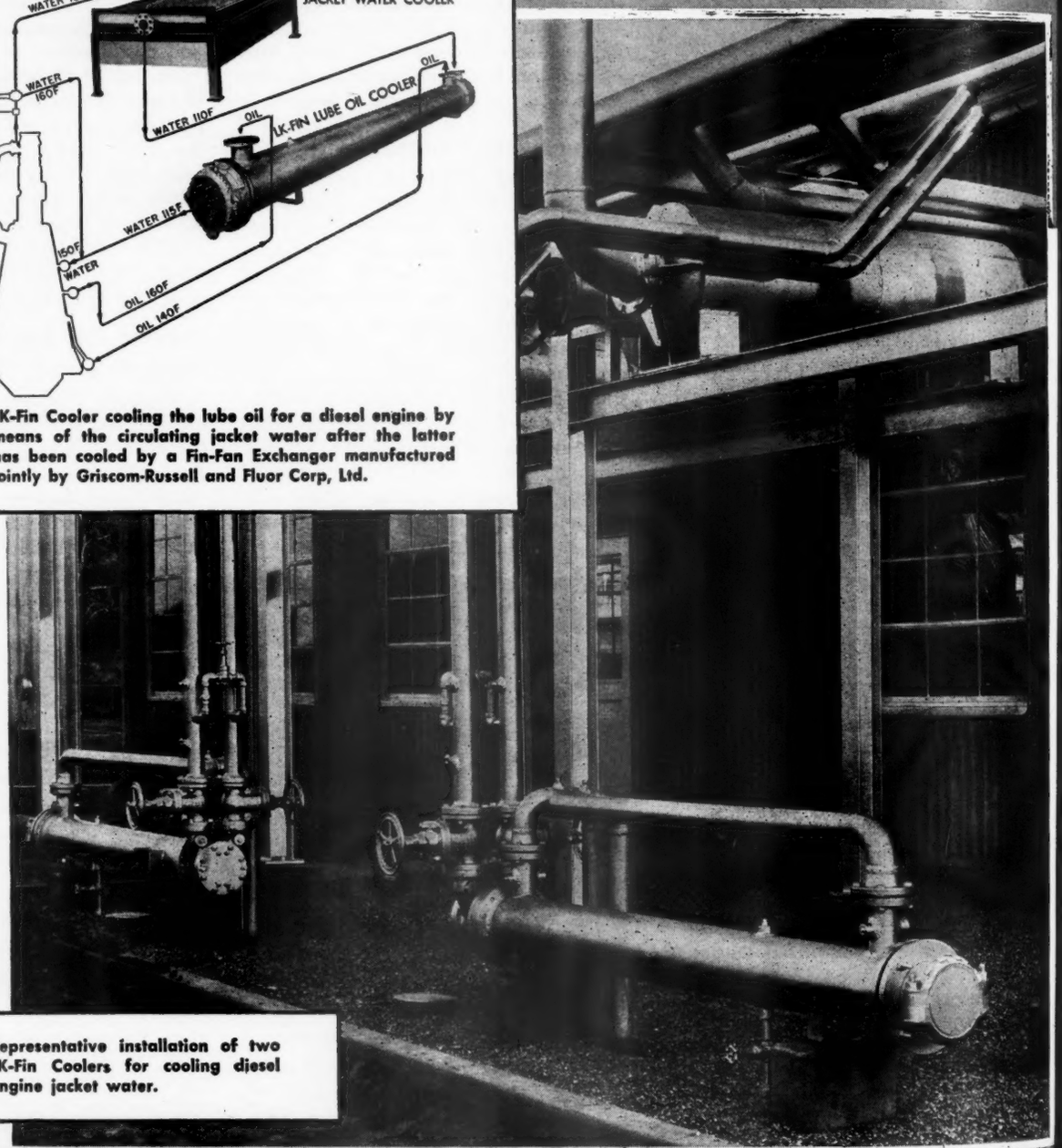
The Distinguished Service Award was granted posthumously to Charles B. Carpenter by Oscar Chapman, Secretary of the Interior, for outstanding technical accomplishments and leadership in the conservation of petroleum and natural gas during 22 years of distinguished service in the Bureau of Mines. The award, the Department's highest honor, was accompanied by a citation and gold medal, and presented by Harry Fowler, who is now chief of the fuels technology division of Region VI at Bartlesville. Mrs. Carpenter accepted the award.

H. B. Hill, formerly supervising engineer of the Bureau of Mines office at Dallas, Texas and now retired, presented the gold medal, and Kenneth Anderson, acting supervising engineer at Dallas, read the citation. The memorial services were attended by a few of Carpenter's many friends in the industry and by the Bureau of Mines employees. Southern Methodist University has established a Charles B. Carpenter Memorial Fund to aid worthy students, particularly, those studying geology and engineering.

Why LK-FIN means a more ef



LK-Fin Cooler cooling the lube oil for a diesel engine by means of the circulating jacket water after the latter has been cooled by a Fin-Fan Exchanger manufactured jointly by Griscom-Russell and Fluor Corp, Ltd.



Representative installation of two LK-Fin Coolers for cooling diesel engine jacket water.

GRISCOM-RUSSELL: PIONEERS IN HEAT TRANSFER APPARATUS

effective, compact, economical LUBE OIL OR JACKET WATER COOLER

It's because of the *fins* on the cooling elements. These fins greatly increase the external heat transfer surface . . . enable a considerably shorter tube to perform the same cooling effect that requires a much longer bare tube.

The results . . . a more compact cooler because of the more effective heat transfer surface . . . a more economical unit because of the shorter tubes and shell.

What diameter . . . thickness . . . pitch . . . should the fins be to accomplish these results? That's where G-R's unmatched know-how comes in . . . a knowledge gained from 20 years of experience in building *finned-type* heat exchangers and the results obtained from many tens of thousands of installed finned-tube units.

And the exclusive use of LK-Fin tubes is only one of the many distinctive features of these coolers. Write for bulletin describing them in detail, with rating tables and selection data.

THE GRISCOM-RUSSELL CO., 285 MADISON AVE., NEW YORK 17, N. Y.

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GR 282

GRISCOM-RUSSELL: PIONEERS IN HEAT TRANSFER APPARATUS

Oil Flow Hike in March

Texas oil producers are bringing in more crude oil this month than last due to continued market demand. The Railroad Commission set the March daily allowable at 2,900,742 bbl, an increase of 71,554 bbl over last month. Indications were that an even greater increase was prevented only by fear of transportation problems involved in getting crude from West Texas to refinery centers. The Commission was told a larger increase would send crude into storage tanks, not because of lack of demand but because West Texas pipe lines would be operating at capacity.

Brown Claims Oil Industry Carries Undue Tax Burden

Treasury Department tax recommendations to Congress singled out the oil industry "to carry an undue portion" of the total tax burden, Russell B. Brown, general counsel of the Independent Petroleum Association of America, said in a report to members of that organization. He stated the oil industry is being asked to account for $1 billion in revenue "over and above the proposed increased rates applicable to all other corporations and individuals. Some seek to impair or destroy the oil industry. They may not understand the merits of depletion provisions as applied to natural resource industries, but are determined to use every possible means of destroying the structural foundation of these industries."

Brown declared that during the 25 years in which the present depletion rate has been in effect the oil industry has explored for, found, and produced ever-increasing supplies of crude petroleum. "Products of petroleum have continuously improved in quality and the distribution and availability of such products have surpassed that in any other country in the world," he added.

He pointed out that Congress established the present rate of depletion because it had to find a method and an amount "that would insure proper tax payments and at the same time not discourage capital investments in such risk industries."

"A shortage of oil that would impair our industrial or security programs would prove disastrous to our national success. A shortage causing excessive cost to the consumer is undesirable."

★ SIMPLIFIED RING CUTTING — Super Seal can easily be pulled down to any shaft or stem size.

★ POSITIVE PACKING IDENTIFICATION — Super Seal styles are clearly marked, each one in a different color.

For many years, SUPER SEAL No. 3 has been achieving outstanding service records in valves and centrifugal pumps handling oils, solvents and petroleum distillates on refinery applications. It is highly recommended for temperatures to 550° F.

Now, with patented "tape-back" construction, SUPER SEAL is easier to use, easier to identify. It's another special "John Crane" feature to insure perfect packing satisfaction.

It's hard to believe the resilience of "tape-back" SUPER SEAL until you twist it down yourself. Send for a sample and try it.

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Kerr-McGee Purchases Crosbie Company Assets

William J. Sherry, Tulsa, Oklahoma independent oil man, has sold most of the physical properties of the J. E. Crosbie, Inc. assets to Kerr-McGee Oil Industries, Inc., Dean A. McGee, executive vice president, announced. Included in the sale were the oil and gas producing properties, some undeveloped leaseholds, the Crosbie interests in four natural gasoline plants in Oklahoma, and drilling rigs. Sherry will retain some of the undeveloped leases, which will continue in the name of the Crosbie company.

The Crosbie assets give Kerr-McGee an additional 1800 bbl of crude oil production, the largest being in Smackover field of Arkansas, in the East Texas pool, the Texas Panhandle, and in southern Oklahoma.

Looking for New Oil

Charles S. Hill, president of the Rocky Mountain Oil and Gas Association, has urged operators in that section of the country to carry their load in finding "at least a million barrels of new oil daily this year." This is the amount the military has asked for to carry on its defense program.

Hill believes the oil industry can carry out the request, provided Congress will not hamper it with efforts to bring the "oil industry under government ownership and control."

Total Imports Rise

Imports of crude oil and refined products into the U. S. averaged 981,700 bbl daily in the week ended February 10, an increase of 111,800 bbl from the level the preceding week, the American Petroleum Institute reported. Crude oil imports were responsible for most of the increase, rising 178,900 bbl daily to an average of 595,800, the third highest level achieved since the beginning of the API reports last August. Residual oil imports hit the lowest point since November 18, averaging 340,900 bbl daily in the week.

The following table includes figures showing the imports of crude oil and residual fuel oil since the four weeks ending January 13.

(Figures in barrels per day)

Week ended	Crude oil	Residual fuel oil	Other Products	Total
Feb. 10.....	595,800	340,800	20,000	981,700
Four weeks ended				
Feb. 10.....	523,200	385,300	30,000	938,500
Feb. 3.....	472,900	416,800	24,300	914,000
Jan. 27.....	490,200	418,900	28,800	937,900
Jan. 20.....	446,600	454,700	27,000	928,300
Jan. 13.....	500,300	444,700	28,000	973,000

Lone Star to Build Steel and Pipe Plant

With a government loan of $73,425,201 in hand, Lone Star Steel Company officials plan to break ground at once in beginning construction of a completely integrated steel mill to be situated adjacent to the firms present blast furnace, coke ovens, and related facilities in East Texas. The loan was recommended by the National Production Authority and authorized by the National Security Resources Board. Reconstruction Finance Corporation will supply $50,000,000. Defense Production Administration will supply the remainder.

Construction of the steel mill in East Texas gives Lone Star the "tightest knit" operation of its kind in the world. Iron ore is mined within sight of the blast furnace. Coal is produced in company mines only 200 miles from the plant site. Consumption of a major portion of the company's production is expected to occur within a radius of 300 miles of the plant.

Lion Oil Booklet

Lion Oil Company has published a booklet containing pictures and facts about its chemical plant and refinery at El Dorado, Arkansas. More than 2300 employees staff these plants at Eldorado, with physical properties valued in excess of $32,000 per employee.

Included in the booklet are several flow sheets, which diagram the atmospheric topping and vacuum reduction unit, Thermofor catalytic cracking unit, the chemical plant, and use of its products.

New Company Magazine

The first issue of Horizons, published by Stanolind Oil and Gas Company, appeared last month. The publication can proudly take its place among the many excellent company magazines in the oil and gas industry. Contents and typography are of outstanding quality.

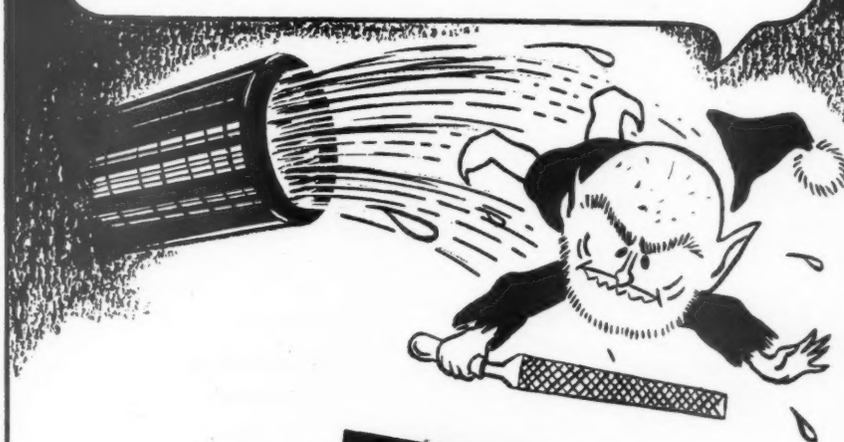
William J. Nash and Keith L. Turley are editor and assistant editor.

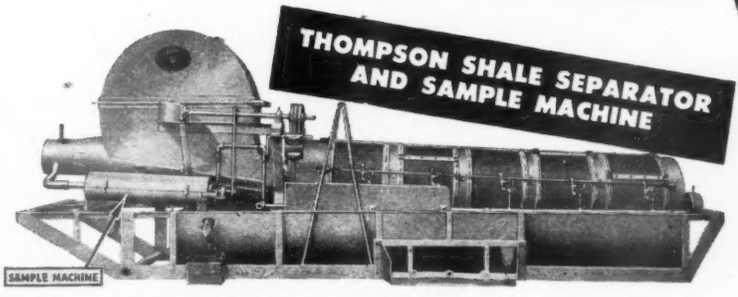
World Crude Output Rises

World production of crude petroleum increased to 10,794,000 bbl daily in August, 1950 a gain of 248,000 bbl over the July production rate, according to a Bureau of Mines report. Larger increases in daily average production were: U. S. 180,000 bbl; Venezuela, 31,000 bbl, and Saudi Arabia 27,000 bbl. Daily average production decreased in Kuwait 9000 bbl, Canada 4000, and Colombia, 3000 bbl. Mexico's production continued its steady rise as production in August exceeded 200,000 bbl daily. Both France and Germany attained record crude production.

"KILLER" SHALE SAYS:

HOW FAR DOWN DO YOU HAVE TO GO TO BE SAFE FROM A THOMPSON SHALE SEPARATOR?





Shale and abrasives don't have a chance to chew up expensive drilling equipment when drilling mud is conditioned with a Thompson Shale Separator... *only clean mud* goes back into the well. If you are drilling deep, you'll want the Thompson "DWF," capable of handling maximum flow from the biggest mud pumps now in operation. Two other models available for shallow and medium depth wells. Attached SAMPLE MACHINE provides accurate foot-by-foot samples of cuttings

For complete data and specifications on all Thompson models, write today for free illustrated folder.

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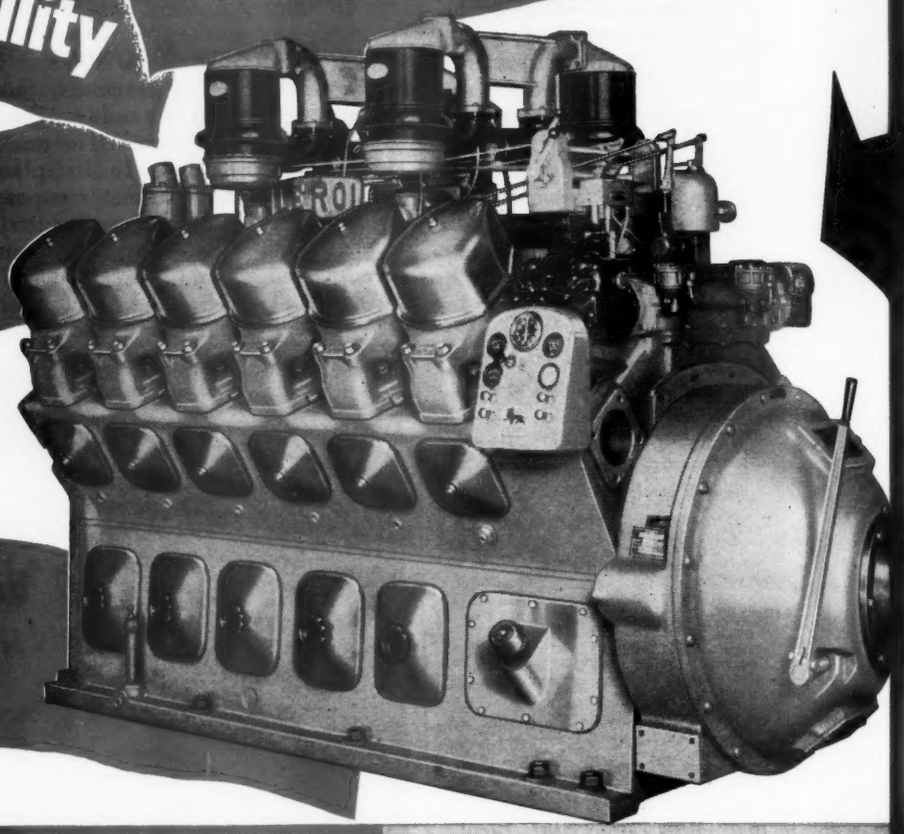
KEEPS DRILLING MUD CLEAN — PROVIDES *TRUE* SAMPLES OF CUTTINGS

Greater Accessibility

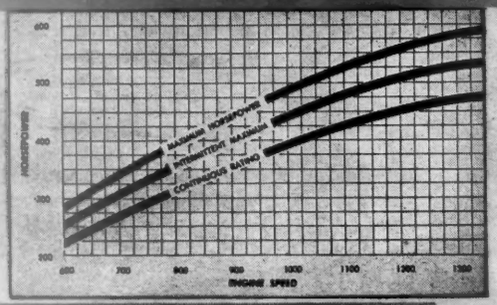
Greater Speed Range

Compactness

More Power

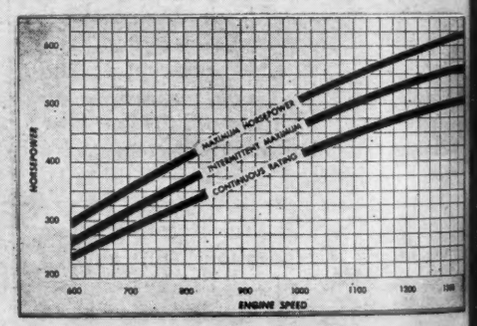


More Power—Wider Speed Range

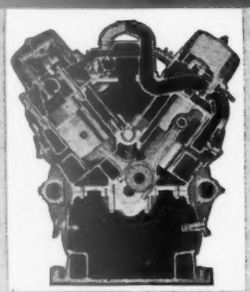


Gasoline or natural gas

Butane

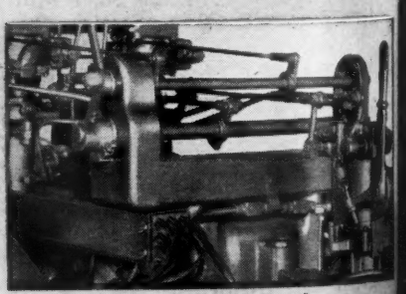


Faster Acceleration



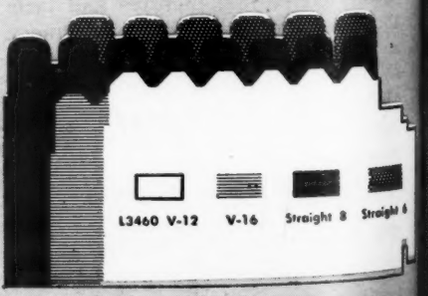
Take a good look at the L-3460's V-12 design. Note the lightweight aluminum pistons, and short-radius rotating parts. You can see why the L-3460 gives you lightning-fast response to load demand.

This governor will interest you, too. It is semi-hydraulic and responds instantly to load changes, whatever they may be.



More Compact—Easy Installation

Just compare the L-3460 with other designs of equal displacement. Remember too, the L-3460 complete with radiator, weighs only 12,200 lbs. That's why the L-3460 saves you installation time and money — is easier to move around.



LE ROI

LeRoi 600hp L-3460

EVERYTHING YOU ASKED FOR IN AN ENGINE

The L-3460, with its 600 maximum horsepower, is designed and built to meet oil-field demands for more power.

Its fast acceleration, wide speed range, lugging power at slow speeds, and compactness make it outstanding for drill-rig applications.

Its dependability and economy under continuous load, its space-saving size for easy installation, and its accessibility that simplifies maintenance give you an unbeatable power unit for any type of oil-field application — drilling, pipeline, generator drives, etc.

Here, in the L-3460, you have oil-field power at its best — wide speed range from 600 to 1350 rpm, and horsepowers from 350 to 600. If you want to keep a tight rein on costs, nothing but the best will do. So let the L-3460 go to work for you now — it's everything you asked for in an engine. For further information, see your Le Roi distributor — or write for our new bulletin E-3.

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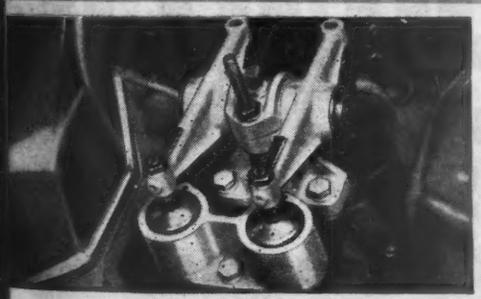
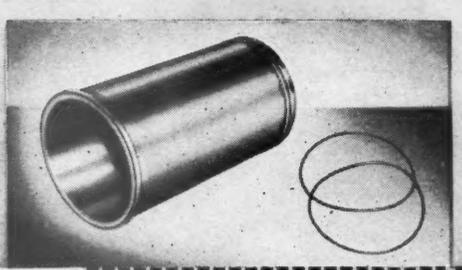
Easier Maintenance—Lower Costs



Valve-in-head design lets one man remove cylinder heads without disturbing manifold, carburetor, or controls.

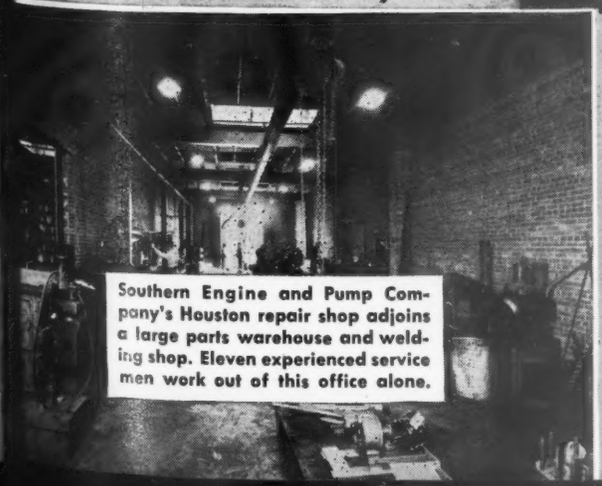
One-piece crankcase and cylinder construction provides unusual rigidity — prevents misalignment. The L-3460 is built to take the punishment of oil-field handling.

Replaceable cylinder sleeves do away with costly reboring and expensive oversize parts.



P-106A

Typical LE ROI service facility



Southern Engine and Pump Company's Houston repair shop adjoins a large parts warehouse and welding shop. Eleven experienced service men work out of this office alone.

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Le Roi Oilfield Sales

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Le Roi Company Branch — Tulsa
Carson Machine & Supply Co.— Oklahoma City

East & South Texas, Gulf Coast
Southern Engine and Pump Company — Houston, Kilgore, Edinburg, Dallas, San Antonio, Corpus Christi, Texas, and Lafayette, Houma, Louisiana.

North & West Texas, New Mexico
General Machine & Supply So. — Odessa, Snyder, Texas.
Nortex Engine & Equipment Co.—Wichita Falls, Texas.

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Western Machinery & Engine Company—Centralia, Illinois and St. Louis, Missouri.

LE ROI

IN THE FIELD . . .

Service Network

Michigan
Hafer Engine Service — Reed City

Rocky Mountain Area
Gehring Equipment Co. — Casper, Wyoming, Rangely, Col.

Northern Louisiana & Mississippi
Ingersoll Corporation — Shreveport, Louisiana, and Jackson, Mississippi.

West Coast
Le Roi-Rix Machinery Co. — Los Angeles, Long Beach and Bakersfield, Calif.

Appalachian Area
P. C. McKenzie Co., Pittsburgh

Canada
Lucey Export Ltd. — Calgary, Edmonton, Alberta.

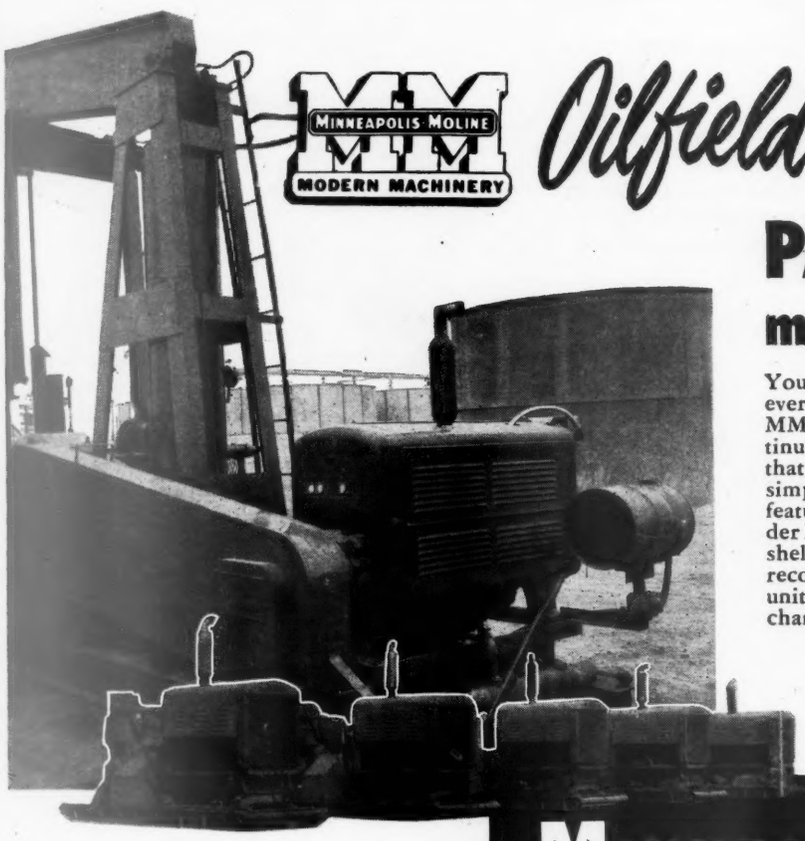
Chicken dinner time at the R. M. Pyles Camp.

The boys keep a clean camp in the High Sierras.

Supports Camps for Children

R. M. "Bob" Pyles, head of the Southwest Exploration Company, Huntington Beach, California, decided two years ago to do something about underprivileged children. Today there are two Pyles' camps, because Pyles and dozens of his friends, all in the oil business, have elected to finance the work. Any oil man anywhere can sponsor a youngster's summer outing for $50. Pyles has arrangements with institutional agencies all over Southern California to supply as many boys as there is money to send them to camp. This year the schedule and the budget calls for 234 boys to enjoy out-of-doors living in the High Sierras.

Besides Pyles, directors of the camps are: S. F. Bowlby, vice president, Shell Oil Company; F. E. Fairfield, Oil Tool Company; L. C. Graves and R. C. Schweitzer, Southwest Exploration Company; R. H. Green, vice president, Signal Oil and Gas; J. M. Hillman, Hillman-Kelley, Inc.; W. G. McComiskey, Signal Hill Electric; and W. A. Smith, W. A. Smith Company.



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You don't pay extra for the years of experience built into every Minneapolis-Moline Power Unit . . . *It Pays You.* MM Oilfield Engines are designed for heavy-duty, continuous operation PLUS a standardized engine design that makes maintenance and service work an amazingly simple job. For example, consider the service economy features in the exclusive MM designed removable cylinder heads and blocks cast in pairs and the precision steel-shell bearings. These two features alone mean low-cost reconditioning or replacement. 4, 6 and 12 cylinder units are identical in design and most parts are interchangeable for easier, low-cost service.

MM engines have an enviable record of continuous duty without mechanical shutdown and are available in 7 sizes from 25 to 180 hp. Only MM Oilfield Engines have built-in Heat Exchanger Base Pans to give you lowest field maintenance!

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PERSONALS

Alan J. Lowrey of San Francisco and **K. E. Kingman** of Los Angeles have been elected vice presidents of Union Oil Company of California.

Lowrey has been assistant to the president since joining Union in 1939. He recently was named president of the San Francisco Chamber of Commerce. He was born in Honolulu and graduated from Harvard, where he played varsity tennis and soccer football. Until his affiliation with Union, he was active in banking circles in Hawaii, San Francisco, and New York.

Kingman, who will serve as vice president in charge of manufacturing, was born in Riverside, California, and was graduated by California Institute of Technology as a chemical engineer. He joined Union Oil as a junior chemist in 1929 and advanced through several assignments to junior engineer by 1932, and manager of the Los Angeles refinery in 1949. He became manager of the company's manufacturing department later that year.

E. F. Battson, W. C. MacMillan, and **J. W. Liddell,** Continental Oil Company, have all been elected to executive positions within the company. Battson was promoted from vice president and regional general manager, Rocky Mountain region, Denver, Colorado, to administrative vice president, Houston, Texas. He joined the company at Salt Lake City in 1922, and served in various assignments in Utah and Montana. He became vice president and regional general manager at Denver in 1949.

MacMillan has been named senior vice president at Houston. He was formerly executive vice president, with offices in that city. With Continental for more than 22 years, MacMillan joined the company in the geological department at Shawnee, Oklahoma. Through various promotions, he was elected vice president in 1943 and executive vice president in 1949.

Liddell, the new vice president and regional general manager, Rocky Mountain region, Denver, was formerly regional manager, Eastern region, New York City. He has been with Continental for more than 25 years. A graduate of Texas A. and M. College, he became regional general manager in New York in 1948.

Donald E. Radtke, formerly petroleum engineer at Magnolia Petroleum Company's Healdton, Texas, producing district, has been transferred to the Shreveport district where he will be in charge of petroleum engineering in the Laurel, Mississippi area. **Martin L. Talley,** formerly petroleum engineer in the Luling district, has been moved to Healdton.

J. W. W. Whitney, Jr., formerly petroleum engineer at Electra, has been transferred to the Shreveport district where he will have charge of petroleum engineering in the El Dorado, Arkansas area.

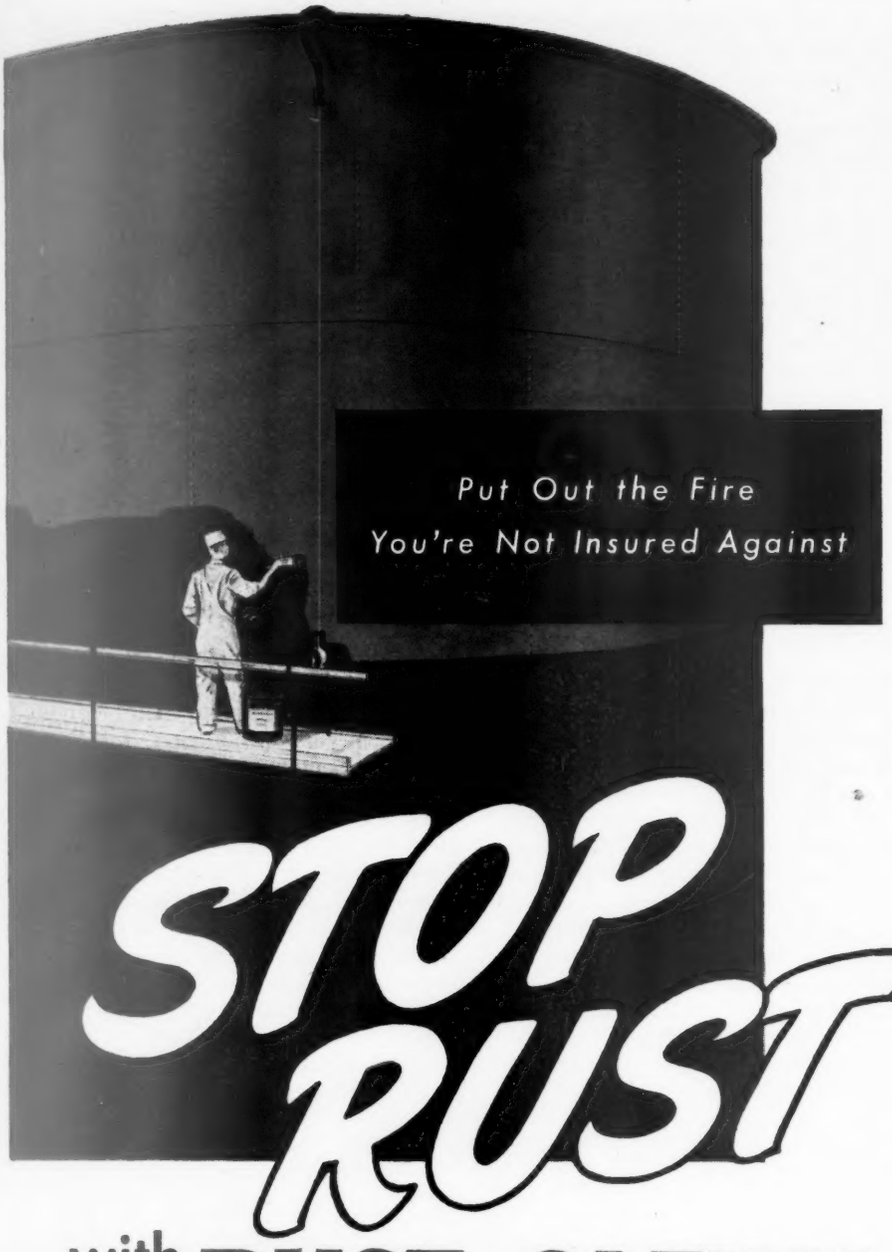
J. A. Crichton

J. A. Crichton, has been named as vice president in charge of operations, including leasing, drilling, development, and production, for San Juan Oil Company.

Crichton was formerly associated with DeGolyer and MacNaughton, Dallas, as vice president and as a past director. He is a graduate of Texas A and M College and Massachusetts Institute of Technology, was employed by Union Producing as a geologist in Houston and Shreveport. He is chairman of the North Texas Section of the American Institute of Mining and Metallurgical Engineers and is a registered petroleum engineer.

Tulsa Nomads' Annual Banquet

The eleventh annual reception and banquet of Tulsa Chapter Nomads was held recently in the Tulsa Club. Dr. Alfred P. Haake, writer and consultant to General Motors Corporation, delivered the address. Officers for 1951 were installed. They are shown in the photo, sitting: Arch F. Campbell, General Motors, sergeant-at-arms; Amos A. Roberts, Baroid Sales Division, president; Dr. Haake; G. F. Coons, National Tube Company, secretary; Gilbert Swift, Well Surveys, Inc., treasurer; R. E. Kirberger, Franks Manufacturing Company, assistant secretary; and standing: R. C. Glover, Baker Oil Tools, Inc., deputy sergeant-at-arms; Opie Dimmick, Century Geophysical Company, regent; J. S. George, Hughes Tool, assistant treasurer; G. W. Davidson, Jr., W. C. Norris Manufacturing, regent; H. M. Cooley, Bethlehem Steel Company, vice president.



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RUST-OLEUM stops rust. It can be applied *even* over rusted surfaces. It is not necessary to remove all the rust. Just use sharp scraper and wire brush to remove loose rust and rust scale.

RUST-OLEUM can be obtained promptly from Industrial Distributors' stocks in principal cities of the United States and Canada. Write on your company's letterhead for complete catalog and nearest source of supply.

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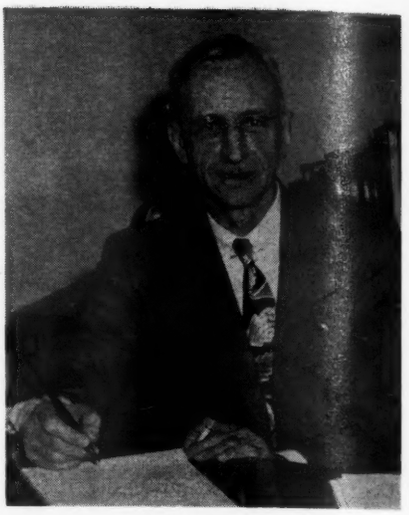


Burdette E. Moir

▸ **Burdette Moir,** head of the petroleum engineering department of Atlantic Refining Company, died of a heart attack at his home recently. Moir, a graduate of the Michigan College of Technology, had been connected with the Atlantic Refining for almost 30 years. He was the company's district superintendent of the East Texas oil fields for several years. He was a member of the Dallas Petroleum Engineers Club.

▸ **Herbert F. Miller,** Tulsa, Oklahoma, vice president and director of The Carter Oil Company, retired from active service February 1, after 48 years service. Miller has headed Carter's crude oil purchasing department since its formation in 1933. He left school in Brooklyn, New York, on completion of the ninth grade and began his petroleum career in 1902 as an office boy in New York with the Standard Oil Company (New Jersey) marine department. In 1909, he became secretary to Walter C. Teagle, former Standard president, in which capacity he made extensive travels in Europe.

▸ **James A. Reid** has been granted a leave of absence from his position as assistant director of research for Phillips Petroleum Company to accept appointment by the Reconstruction Finance Corporation as assistant manager, office of production, Washington, D. C.

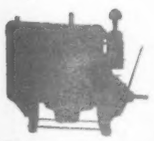
Reid joined the Phillips organization in 1933 as a research chemist. Subsequently he occupied several other research and supervisory positions in the research department. In February 1943, he was granted leave of absence to join Rubber Reserve Company. On his return to Phillips in 1944, he became assistant to the vice president in charge of research and development.

"LOWEST COST pumping operation I know of," says L. M. Lott, pumper for J. B. Daniels, Fairfield, Texas.

Pumps for Pennies

International U-6 pumps 59,904 hours on Texas well.

Cost of lubricating oil and replacement parts only 4/5 cent per hour!



This is no Texas "brag!"

This is fact: J. B. Daniels, Fairfield, Texas, has used this International U-6 on a pump jack for 59,904 pumping hours. Fuel is waste natural gas. The only expenses—lubricating oil and repair parts—cost only four-fifths of a cent per hour.

That's the economy of International power. Here are more reasons to buy: Smoothness of multi-cylinder operation, built-in endurance and adaptability. Service facilities throughout the oil fields. And if you buy on reputation—mister, you'll buy International!

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Please send me a copy of your catalog, A-384-NN International Oil Field Pumping Engines.

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▸ **Lowell A. Kern** has joined the headquarters staff of the American Petroleum Institute to handle agricultural services. He came to the API from Swift and Company, Chicago, Illinois, where he had been in charge of that company's agricultural information program. He will devote full time to the program.

Kern will be at the New York offices where he will be affiliated with the Department of Technical Services, under the direction of **D. V. Stroop.**

Ladd Haystead, nationally known agricultural editor and writer, will continue as counselor on agriculture to the API.

▸ **Charles M. Cotton,** former vice president and general manager of Jergins Oil Company, and **Lowell Stanley,** former vice president and treasurer, became chairman of the board and president, respectively in a reorganization following purchase of stock control of the company by eastern and coast investors recently.

On the board of directors are **Frederick L. Ehrman, John R. Fell** and **Joseph A. Thomas,** all of New York; **William T. Sesnon,** Beverly Hills; **Marco F. Hellman,** San Francisco; Cotton, and Stanley.

Officers of the reorganized company in addition to Stanley and Cotton are **Ernest Pyles, John H. Abramson,** and **Charles Pickering,** vice presidents; **Charles Pierce,** treasurer; **William Davidson,** secretary; **Marshall E. Dunn,** controller, and **Martin Erck,** assistant secretary. All the officers are veterans of the company.

A. C. Long

▸ **A. C. Long,** vice president of The Texas Company in charge of foreign operations in the eastern hemisphere, has been elected an executive vice president with headquarters in New York. He will be responsible for all foreign operations in both eastern and western hemispheres.

Long attended Marion Institute, Marion, Alabama and was graduated from the U. S. Naval Academy in 1926. After serving approximately four years in the U. S. Navy, he joined The Texas Company in 1930. He served in Ireland from 1931 to 1934, when he was transferred to The Hague, Netherlands, as manager of the Dutch subsidiary. Elected vice president in charge of foreign operations, Eastern Hemisphere in 1949, he was named a director last year.

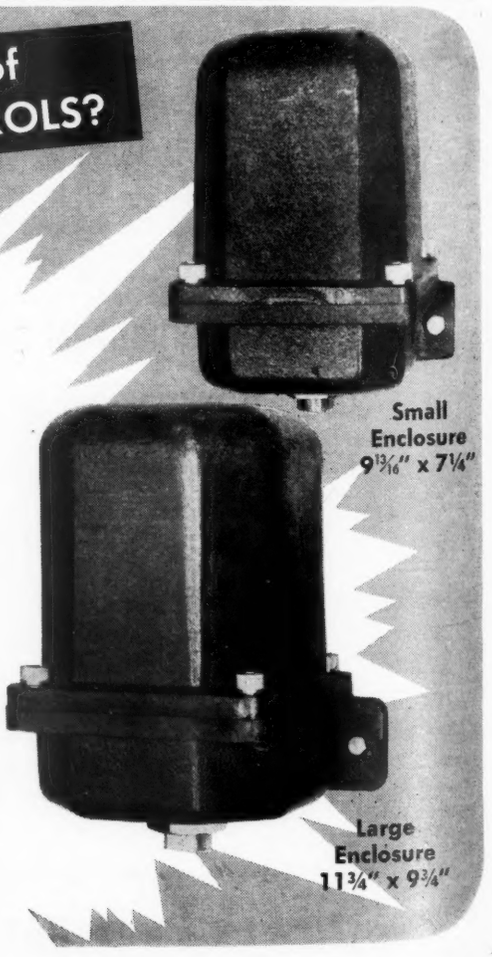
▸ **H. A. Grimes** has been elected director of Creole Petroleum Corporation, to fill the vacancy left by the resignation of **C. L. Burrill.** Grimes has been associated with the oil industry for 28 years, most of which time was spent with Creole in Venezuela. His career with Creole began in 1922 when he was employed as a field engineer. With the exception of short temporary assignments in New York and a period of 4 years (1945-1949) when he was general manager of the International Petroleum Company, Ltd., in Peru, Grimes has been continuously in the employ of Creole in Venezuela. His latest assignment, prior to his election as a director, was member of the management committee in Venezuela.

Why Specify "NEMCO" Explosion-Proof PRESSURE AND TEMPERATURE CONTROLS?

Designed for use in Class 1, Group D Hazardous Locations, "NEMCO" Explosion-Proof Cast Iron Enclosures for housing pressure and temperature control units—

1. Provide maximum ease in mounting and piping.
2. Give complete access to all control adjustments by removing cover of enclosure.
3. Can be drilled for special conduit openings where desired.
4. Are manufactured in two different enclosure sizes, illustrated herewith, to accommodate the various control units required for a wide range of pressures and temperatures.
5. Enclosure can be purchased complete with control mounted inside; or the enclosure only can be furnished.

High tensile gray iron castings for enclosures are produced in our "NEMCO" Foundry and prompt delivery is assured. Let us quote on your requirements.



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BIBLIOGRAPHY—Classified list of important papers for 1949 - 1950

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LAUGH with BARNEY

The average girl needs beauty more than brains because the average man can see a lot better than he can think.

A tourist in the Ozarks called to the old woman sitting on the porch, "How far is it to the nearest town?"

"Pa figgers it's about ten miles thar, and about 12 back," she answered. "Which is on account of him walkin' straighter goin' than comin'."

A farmer was anxious about his prize cow. It had wandered off somewhere out of sight.

The farmer's little granddaughter from the city was helping look, but didn't seem to be worried.

"She can't go far, Grandpa," the child said. "I saw you draining her crankcase last night."

After several hours of luckless fishing the little city girl suddenly threw down her pole and cried, "I quit!"

"What's the matter?" her grandfather asked.

"Nothing," said the child, "except that I can't seem to get waited on."

Some of the girls have discovered that you get out of a sweater only what you put in it.

Office Boy (nervously): Please, sir, I think you're wanted on the 'phone.

Employer: You think! Don't you know?

Office Boy: Well, sir, the voice at the other end said, "Hello, is that you, you old idiot?"

The sign was posted: "Fine for Parking."

Officer to offending couple: "Can't you read the sign?"

Driver: "Yes, officer, and I heartily agree with it."

Son: Dad, what was your great ambition when you were a boy?

Dad: To wear long pants. And I've had my wish. If there is anybody else in the country that wears his pants longer than I do, I'd like to see him.

Switchboard Operator: Sorry, Madam, but Mr. Edwards has just gone to lunch with his wife.

Mrs. Edwards: Oh, well, then tell him his stenographer called.

Little Boy (at football game): Mom, why do all the men with good seats have bald heads?

Mother: They got their tickets from scalpers, dear.

Two gentlemen sat in their hotel room consuming a quart of spirits. One of them had an idea and raised the window. "I'm going to take off and fly around the courtyard a little bit," he remarked boldly. Leaping from the window sill, he buried his nose in the cement three floors below. The next day his friend went to the hospital to see him.

"I certainly made a fool of myself yesterday," said the patient. "Why didn't you stop me?"

"Maybe I should have," meekly replied his friend, "but at that time I really thought you could do it."

A district attorney was having trouble with one of the witnesses, a rather pugnacious old man.

"Are you acquainted with any of the jurymen?" asked the district attorney.

"More than half," grunted the witness.

"Are you willing to swear that you know more than half of them?"

The old man flicked a glance over the jury box. "If it comes to that," he drawled, "I'm willing to swear I know more than all of them put together."

Bars are something which if you go into, you are apt to come out singing a few and maybe get tossed behind.

A father inspected his daughter's new bathing suit, and remarked caustically, "Ethel, it is just big enough to prevent your being tanned where you ought to be."

"Has James changed much in the years he has been away?"

"No, but he thinks he has. He keeps talking about what a fool he used to be."

Definition. A Communist is a guy who borrows your pot to cook your goose in.

Professor: What is the outstanding contribution that chemistry has given to the world?

Student: Blondes.

"Yes, Sir! I'm a self-made man."

"Lucky guy! I'm the revised work of a wife and three daughters."

Teacher: What's half of 8?

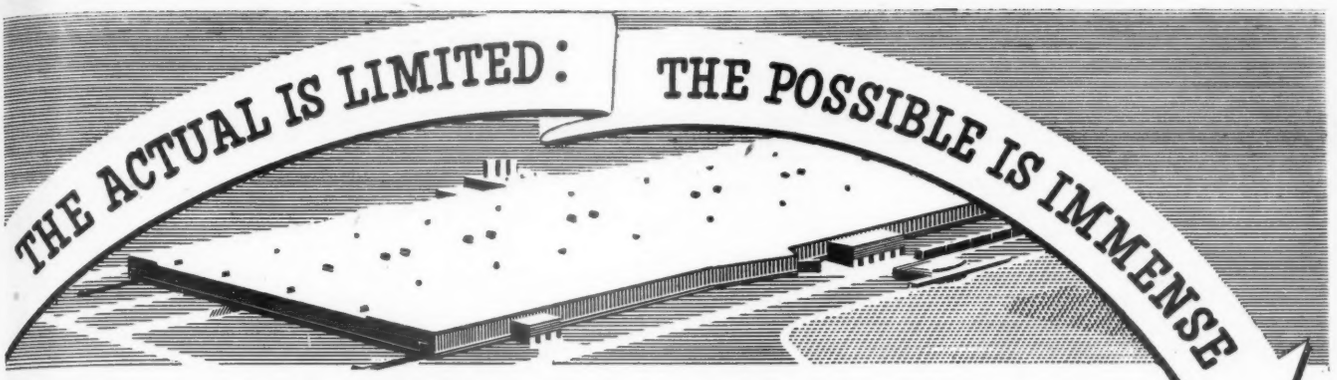
Johnny: Which way?

Teacher: What do you mean, which way?

Johnny: Up and down, or sidewise?

Teacher: What difference could it possibly make?

Johnny: Well, the top half of 8 is zero, but half of 8 sidewise is three.



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

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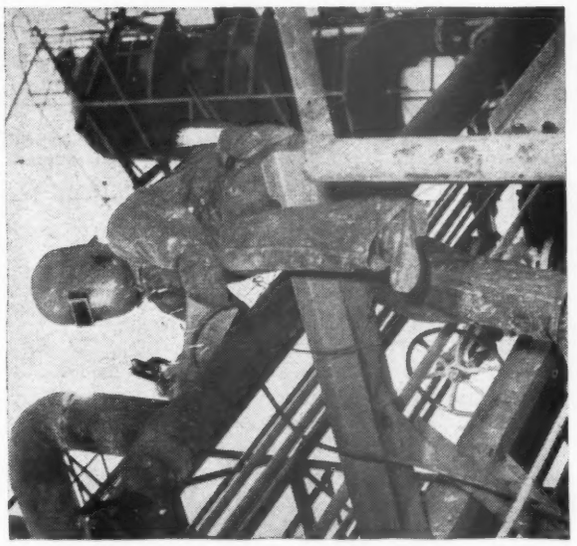
Speeds construction of topping and reforming unit

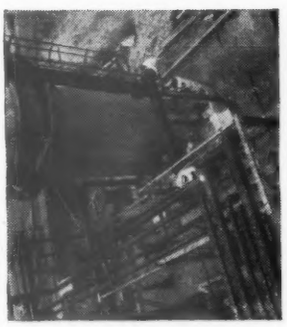


6" gas line for 600-lbs. pressure at the Southwestern Oil and Refinery Co., Corpus Christi, Texas is welded with "Fleetweld 5" electrode. All joints are bevelled 30° and arc welded with 3 passes of 5/32" diameter electrode.

FABRICATIONS of all types are being greatly simplified . . . completed in less time with fast, dependable Lincoln arc welding. As in the refinery construction shown, "Fleetweld" electrodes are producing highest quality welds at lowest cost on all structural members, gas and steam lines. On stainless steels required for processing pipe and pressure vessels, reliable welds result from Lincoln "Stainweld" electrodes.

Latest Procedures For Cutting Welding Costs are presented in the new 9th Edition Procedure Handbook of Arc Welding Design and Practice. Price only $2.00 postpaid in the U.S.A.; $2.50 elsewhere.

A new stainless steel liner is being installed in this tank. Liner sections are first plug welded to the tank wall and then butt welded with Lincoln "Stainweld" electrodes.



8" pipe for 500-lb. super-heated steam line is being butt welded with "Fleetweld 5" and using Lincoln "Shield-Arc" Engine Driven Welders.

CUTTING END-OF-SERVICE COSTS

Increases Life Of Tool Joints *by adding Lincoln hardsurfacing to worn faces. Reclaimed tool joint is permanently stronger to resist fatigue stresses set up by whipping action of drill pipe.*

RECLAIMING CRITICAL MATERIALS

Beats Pipe Shortage *by reclaiming pitted pipe . . . filling in corroded areas with Lincoln "Fleetweld 5" as on the 16-inch pipe shown for oil, gas and gasoline lines.*

SEE HOW LINCOLN WELDING SIMPLIFIES REFINERY FABRICATION

Lincoln Weldirectories for Mild Steel and Stainless steel are available upon request on your letterhead. Write Dept. 182,

THE LINCOLN ELECTRIC COMPANY

CLEVELAND 1, OHIO

Oil and Gas Trade News

Check Valve Agents Named

Activity in circle seal check valves, manufactured by James-Pond-Clark of Pasadena, California, has increased to such an extent that it was recently necessary to appoint three stocking-distributors. These check valves will soon be available from stock in New York, Chicago and Dayton, P. F. Shepherd, sales manager, announced on his return from a trip to the East. They will be distributed by: The Norman Engineering Company, 2035 W. Charleston, Chicago, Illinois; The Nielsen Hydraulic Equipment, Inc., 298 Lafayette Street, New York 12, New York, and The Scott Equipment and Engineering Company, 1316 Lorain Avenue, Dayton, Ohio.

National Supply, Atlas Consolidate Divisions

The National Supply Company's engine division has completed a consolidation of its sales and service facilities with those of the Atlas Imperial Diesel Engine Company. The purchase of the assets of Atlas Engine Company by National Supply was consummated on July 24, 1950. This consolidation now enables the company to offer extensive sales and service facilities on National's Atlas and Superior diesel, gas, dual-fuel, and Chrysler marine gasoline engines, F. H. Kilberry, engine division general manager, stated.

Buys Loffland Interest

R. W. Wire, president of Loffland Brothers Company, oil well drilling contractors with headquarters in Tulsa, Oklahoma, has announced that Loffland Brothers Company have recently acquired The Chicago Corporation's interest in Loffland Brothers. Wire states further that no change in the present management or policies of the company is contemplated.

Construct Amine Plant

Construction of a plant to produce amines, amides, and nitriles from animal and vegetable oils has been announced by General Mills, Inc., Minneapolis, Minnesota. Situated at the company's Chemoil plant in Kankakee, Illinois, the new unit is scheduled to begin pilot operation in the fall of 1951. Designed by General Mills research laboratories, the plant follows an intensive research program. Its completion will mark General Mills' entry into the fatty amine industry. The company, however, has been a producer of vegetable oil fatty acids since 1948. General Mills research laboratories will be responsible for initial operation of the plant. Standard products will be merchandised by General Mills but new derivatives will be introduced by the new products commercial research department of the research laboratories.

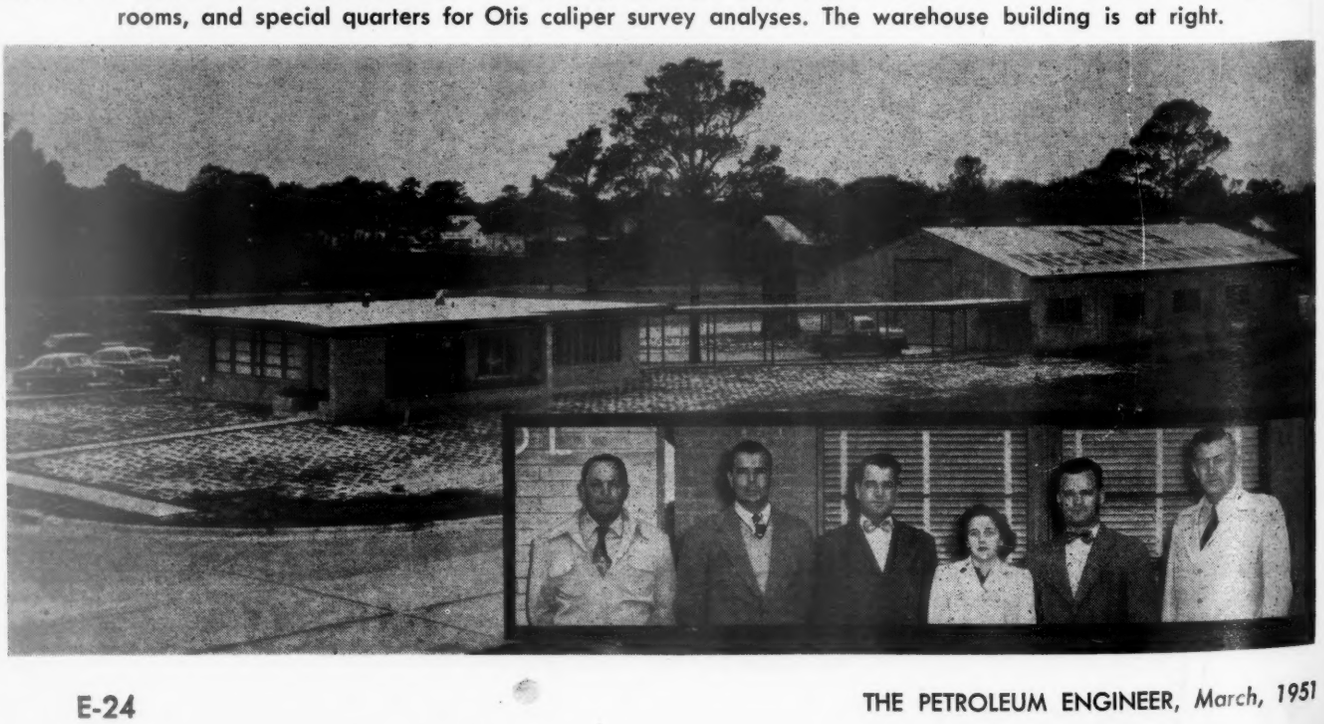
Appoint Mexican Agents

The Cleco division of the Reed Roller Bit Company, Houston, Texas, has announced the appointment of Montes y Valles, S. A., Vallarta 1—305B, Mexico 4, D. F., as distributors of Cleco products in that area. In addition to handling the full line of Cleco pneumatic tools, Montes y Valles will maintain complete stocks of Cleco parts and accessories for the convenience of customers in their territory. The line includes tools for construction, manufacturing, metal fabrication, foundries, industrial maintenance, and stone carving.

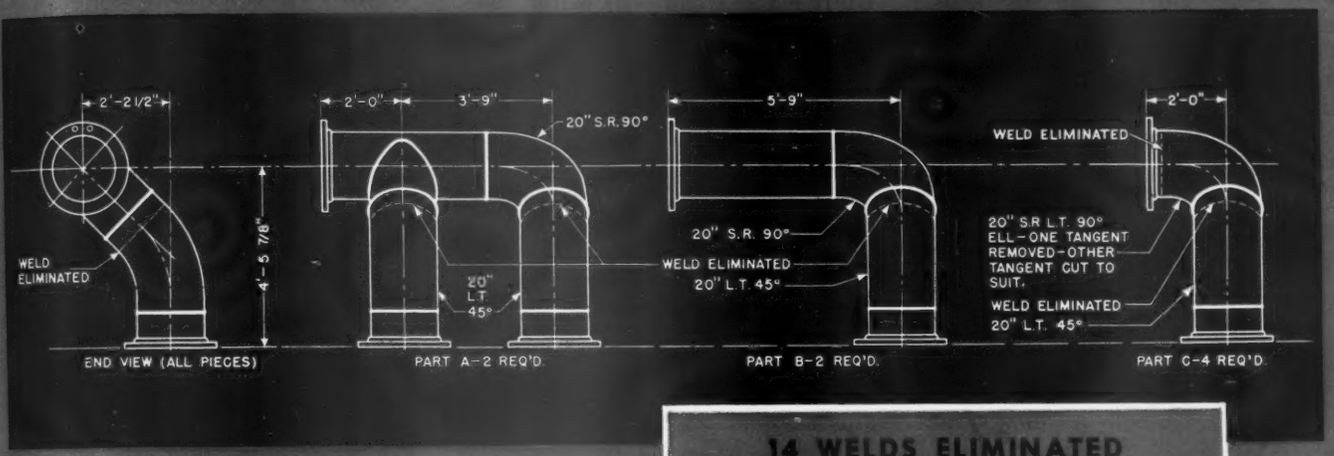
Otis Pressure Moves to New Houston Offices

Otis Pressure Control's Houston, Texas, division has moved into recently completed offices and warehouse at 2402 Broad Street at Gulf Freeway. Offices, sales rooms, and special quarters for Otis Tubing caliper survey analyses are in the building on the left; (accompanying photograph), equipment and tools are serviced and shipped in the warehouse building at right. In inset, are Jack Rogers, assistant superintendent; D. E. Daffin, superintendent; Guy Gant, office manager; Mrs. Marian Pearson, secretary; Kenneth W. Robbins, caliper engineer, and Turner G. Garwood, Gulf Coast sales manager.

New home of Otis Pressure Control, which has just recently been completed in Houston, Texas. At left are offices, sales rooms, and special quarters for Otis caliper survey analyses. The warehouse building is at right.



12% COST REDUCTION... *in these piping subassemblies*



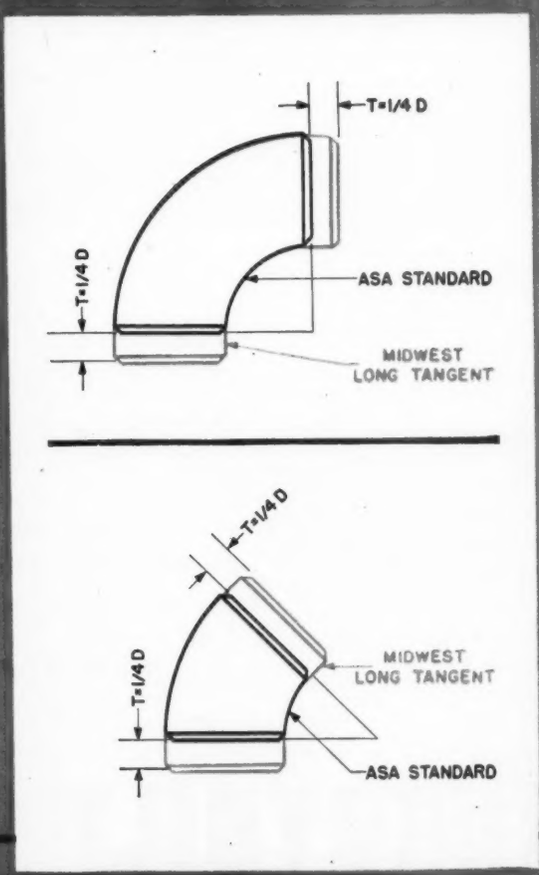
14 WELDS ELIMINATED
9'-8" OF 20" PIPE SAVED

with MIDWEST "LONG TANGENT" ELBOWS

Here is a concrete example of the extra cash value of Midwest "Long Tangent" Elbows. They saved 12% of the cost of this piping.

Each of the subassemblies shown above, if made of ASA elbows, would have required an extra nipple with an extra weld at the dotted line. With the Midwest Long Tangents, both the nipples and the welds were eliminated. Reduced material and labor costs made this substantial saving.

Other advantages of Midwest "Long Tangent" Elbows: pipe and fitting lined up more quickly and accurately, weld is removed from point of maximum bending stress, can be sleeved, slip-on welding flanges are more easily used, and they cost no more than standard elbows usually furnished. Ask for Catalog 48.



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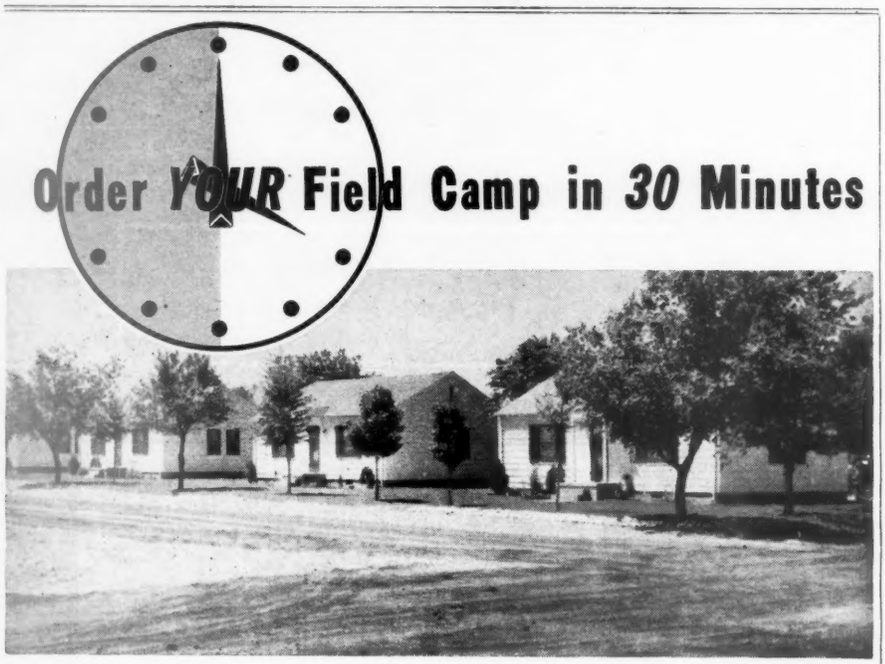
The Happy Company Holds Annual Sales Meeting

Happy representatives from the Mid-Continent producing area convened at the company's home office in Tulsa, Oklahoma, recently for a 3-day session of meetings with the overall purpose of studying and discussing the serious problems at hand to better serve the oil industry. In attendance, in addition to local personnel, were the following division managers: F. E. (Dusty) Rhoads, E. L. (Bus) Williams, Ed Allan, R. B. (Cotton) Rundle, Harold Ashworth, B. E. Shelton, Jack Simpson, John Ritter, and Charles Stanley, assistant division manager, Odessa, Texas.

Paul E. Mahaffey, president, and Leo C. King, vice president in charge of sales, announced a new line of twin-crank, chain driven pumping units. The designs are completed and all models are now in production. Other equipment distributed by Happy includes sheaves, V-belts, all types of BWH flat and conveyor belting, belt dressing, belt tighteners, Vortox air cleaners, Murphy control switches, oil level control assembly, stuffing box rubbers, Hap-Alloy balls and seats, polished rod clamps, transmission equipment, and other related items.



MANUFACTURERS OF SPECIAL MILLWORK: DISTRIBUTORS OF JOHNS-MANVILLE BUILDING MATERIALS: CURTIS WOODWORK

In a half hour you can choose the STURDYBILT, prefabricated, demountable houses you want, place the order, and know your camp will be ready when you want it. Homes, warehouses, tool houses, garages and bunk houses have been designed to suit your needs, and are ready for your selection.

Write for Information

STURDYBILT
SOUTHERN MILL & MANUFACTURING CO.
Tulsa, Oklahoma
Prefabricated, Demountable Houses

STURDYBILT HOUSES COMPLY WITH COMMERCIAL STANDARD CS125-45 OF THE NATIONAL BUREAU OF STANDARDS FOR PREFABRICATED HOMES

Ken Davis Buys Unit Rig Company

Unit Rig and Equipment Company, Tulsa, Oklahoma, one of the largest designers and manufacturers of oil field equipment and ditching machines in the country, has been sold to Ken W. Davis, Fort Worth, Texas. He is taking over all the stock of Unit Rig. Included in the deal is 42,000 sq ft of property, recently acquired by Unit Rig, covering the west half of the block directly north of the present plant.

Officers of the company are William Guier, president; Ray E. Carter, executive vice president; J. H. (Jack) Smith, vice president and chief engineer, and F. C. Morton, secretary-treasurer.

Greer Builds New Plant

Greer Hydraulics, Inc., has broken ground for the construction of a new plant adjoining its existing facilities at 454 Eighteenth Street, Brooklyn, New York. Greer Hydraulics, Inc. is a major manufacturer of aircraft testing equipment, hydro-pneumatic accumulators and hydraulic components, serving the United States Air Forces, United States Navy, Bureau of Aeronautics, and other governmental agencies, airplane engine manufacturers, domestic and foreign airlines, and industry in general. It has become necessary for the company to increase its facilities to satisfy requirements for new and improved equipment to test and maintain reciprocal and jet turbine type engine aircraft. Increased facilities will also enable the company to increase production of the Greer hydro-pneumatic accumulator and other hydraulic products. It is expected that the new plant will be completed and in operation on May 15, 1951.

Re-enter Gas Main Work

United Engineers and Constructors, Inc., Philadelphia, Pennsylvania, has announced the re-entrance of that company into gas main construction work. C. A. Schlegel, vice president and gas sales manager, stated that due to the considerable amount of work in gas main extensions occasioned by the coming of natural gas to the East, United Engineers would once more offer this type service to the public. Construction personnel has been augmented, Schlegel reported, to meet the needs of gas main work, and the company is now in a position to provide complete and flexible engineering, construction managing, and inspection services or any portion needed to supplement the regular forces of utility companies.

Rockwell Buys Ohio Company

W. F. Rockwell, Jr., president of Rockwell Manufacturing Company has announced the acquisition of both the Pittsburgh valve and fittings division of the Pitcairn Corporation, and the Pittsburgh valve and fittings corporation, a subsidiary of the Pitcairn Corporation. Manufacturing facilities and principal offices of Pittsburgh Valve are in Barberton, Ohio. Company-owned warehouses were also acquired in Kansas City and Houston.

Rockwell says that his company intends to expand Barberton operation in order to make fullest use of the facilities for the production of Rockwell products. The plant will be operated as one of Rockwell's meter and valve divisions under the direction of L. A. Dixon, vice president. R. G. Caouette, at present general manager in charge of manufacturing for the meter and valve division of Rockwell will become general manager of the Barberton property. J. A. Strachan, general manager of sales of Pittsburgh Valve, will continue in that capacity as will all district managers and a sales staff of 25 persons. Rockwell manufactures a diversified line of products including machine tools, meters, valves, control devices, and computing mechanisms.

CTI Formed to Help Conserve Water

The practical encouragement of all efforts, both governmental and private, toward the conservation of water as America's No. 1 natural resource has been announced as the primary objective of the newly-formed Cooling Tower Institute, according to Raymond C. Kelly, president. Speaking on the reasons for the formation of the Cooling Tower Institute, Kelly said, "Emerging in the early 1930's as a separate and distinct industry devoted directly to the conservation of water, the cooling tower industry has grown more than 10 fold in 20 years and today finds itself in the family of major industries."

The member companies, their present delegates, and Cooling Tower Institute officers elected for the first term are: The Fluor Corporation, Ltd., J. R. Fluor, first vice president; Foster-Wheeler Corporation, J. A. Brown, second vice president; Hudson Engineering Corporation, N. B. LauBach, delegate; Lilie-Hoffmann Cooling Towers, Inc., P. R. Hoffman, delegate; The Marley Company, Inc., L. T. Mart, secretary-treasurer; J. F. Pritchard & Company, Raymond C. Kelly, president, C. H. Wheeler Manufacturing, H. R. Baker, Jr., delegate.

Worthington Names Haslam To Board of Directors

Robert T. Haslam has been elected to the board of directors of Worthington Pump and Machinery Corporation, Harrison, New Jersey. Haslam was, until recently, a vice president and director of Standard Oil Company (New Jersey). A director and member of the executive committee of Ethyl Corporation, he also is a member of the Corporation of Massachusetts Institute of Technology. Graduating from MIT in 1911 Haslam then joined its faculty.

R. T. Haslam

Pacific Pumps Man Dies

Ralph C. Van Matre, 51, vice president and general manager of the Mid-Continent division of Pacific Pumps, Inc., died in his sleep on January 11, in Wichita Falls, Texas. The popular and civic minded executive has been a resident of Tulsa for the past 5 years. Previously he had lived in Oklahoma City, Dallas, and Houston while sales manager, Mid-Continent division for Pacific Pumps.

For WEATHERPROOF Oil Field Power
STANDARDIZE ON
WISCONSIN ENGINES

Here are good examples of dependable oil field power units at work! These pumps are powered by compact, Wisconsin Heavy-Duty Air-Cooled Engines. Each works in an isolated area, with a minimum of servicing.

Just as important as this advantage is the fact that Wisconsin Engines work efficiently during the hottest summer weather or the coldest day of winter, through rain or snow. Wisconsin Engines are weatherproof and practically fool-proof! Such features as tapered roller bearings at both ends of the crankshaft, fool-proof, all-weather air-cooling, and heavy-duty construction throughout are the reasons why Wisconsin Engines handle the job . . . the reasons why over 1,500,000 have been sold as independent power units and power components on a great variety of original equipment, representing a record total of over 18,000,000 available hp.

4-cycle single-cylinder, 2-cylinder, and V-type 4-cylinder models, 3 to 30 hp.

WISCONSIN MOTOR Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
510 ATLAS BUILDING, TULSA, OKLAHOMA
M & M BUILDING, HOUSTON, TEXAS
505 SOUTH MAIN ST., WICHITA, KANSAS
OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS.

ARMSTRONG BROS.
Better PIPE TOOLS

Reversible Ratchet STOCKS and Adjustable DIES

Exceptionally convenient where space is limited, this stock simplifies pipe threading close to walls, in corners and wherever operating room is restricted. With *adjustable* dies (cut exact, over or under size threads) it is an ideal tool where valves and fittings are being installed or maintained.

"ARMSTRONG BROS." Adjustable Dies are of special Vanadium Tool Steel, have "backed-off" teeth, correct cutting angle, ample chip clearance and correct throat angle. They start and cut easily, hold their sharpness and "spin" off pipe without jamming or tearing threads.

Write for Catalog

ARMSTRONG BROS. TOOL CO.
"The Tool Holder People"
5231 W. ARMSTRONG AVENUE • CHICAGO 30, ILL.

Sales Offices Opened

T. D. (Hi) Collins, vice president Ideco supply stores division, recently announced the opening of sales offices in Midland, Texas. George W. H. Bush, city sales representative for Midland, will be in charge. The new offices are situated on the ground floor of the Petroleum Building, Midland, Texas.

Enterprise Employees Meet In Sonoma, California

Enterprise Engine and Machinery Company held its annual sales meeting, at Sonoma Mission Inn, California, recently, where members of the national sales organization joined the home office personnel for a 3-day session.

Those participating included: Seated, J. E. Watson, general sales manager; W. E. Clayton, Jr., secretary; J. W. Coombs, member of the board of directors; W. E. Butts, president; P. I. Birchard, vice president and general manager; H. T. Anderson, district manager, New York; G. B. Wright, representative, Chicago; G. C. Rasey, sales manager, engine division.

Second row: P. B. Erwin, district manager, Los Angeles; L. J. Robbins, district manager, St. Louis; W. H. Porter, district manager, Seattle; T. S. White, technical engineer; H. G. Bahr, manager, service department; J. M. Maag, representative, Kansas City; K. F. Cramer, representative, Kansas City; D. S. Briese, advertising manager; H. J. Dauphinee, export sales; H. F. Neuman, stationary sales.

Back row: G. J. Brusher, marine sales, H. H. Goodwin, sales engineer, New York; P. K. Wabnig, district manager, New Orleans; W. E. Bishop, representative, Washington, D. C.; J. E. Barthmaier, district manager, Boston; M. T. Prendergast, manager, parts department; W. Malone, sales engineer, Chicago; H. L. Hansen, chief service engineer; T. S. Pennebaker, district manager, Fort Worth; J. H. Sheusner, chief engineer.

Hassebroek Named To Head New Post

Creation of a new post, technical supervisor of Hydrafrac service operations, has been announced by Halliburton Oil Well Cementing Company. Named to fill the post is Willard Hassebroek, Halliburton development engineer. Currently, Halliburton has expanded its Hydrafrac process operations throughout the United States, and is moving into foreign fields with the process. Hassebroek graduated from Oklahoma A & M College in 1935 with a B.S. degree in chemical engineering. With Halliburton for the past 16 years, he has worked throughout the Mid-Continent area as a field engineer, and since 1942 has been at Duncan, Oklahoma, where Halliburton's home office is situated.

Worthington-Gamon Division Formed

Worthington-Gamon Meter Company, Newark, New Jersey, formerly a subsidiary of Worthington Pump and Machinery Corporation, has been made a division of that corporation. The new division will continue the manufacture of liquid meters at the former company's Newark plant, according to H. C. Ramsey, president of Worthington Pump. Robert R. Anderson, formerly president, Worthington-Gamon, has been elected vice president of Worthington Pump and will act as general manager of the new division. William C. Flanders, formerly vice president of the meter company, has been appointed assistant general manager of the division and Walter H. Zeis, formerly secretary and treasurer of the meter company, has been elected assistant secretary of the Worthington corporation.

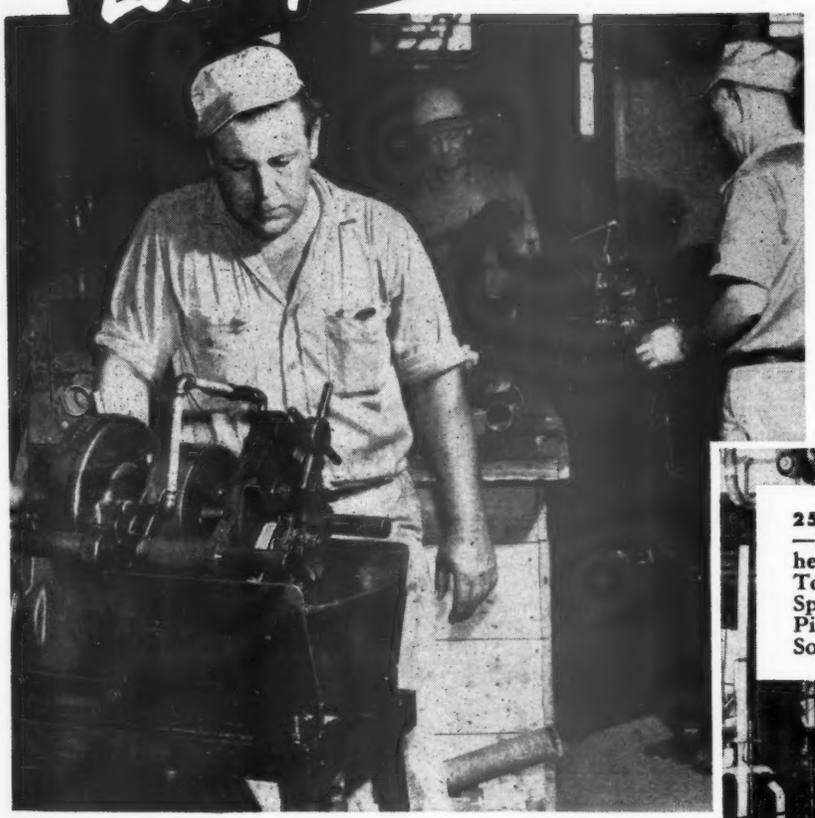
R. R. Anderson

Odessa Branch Opened

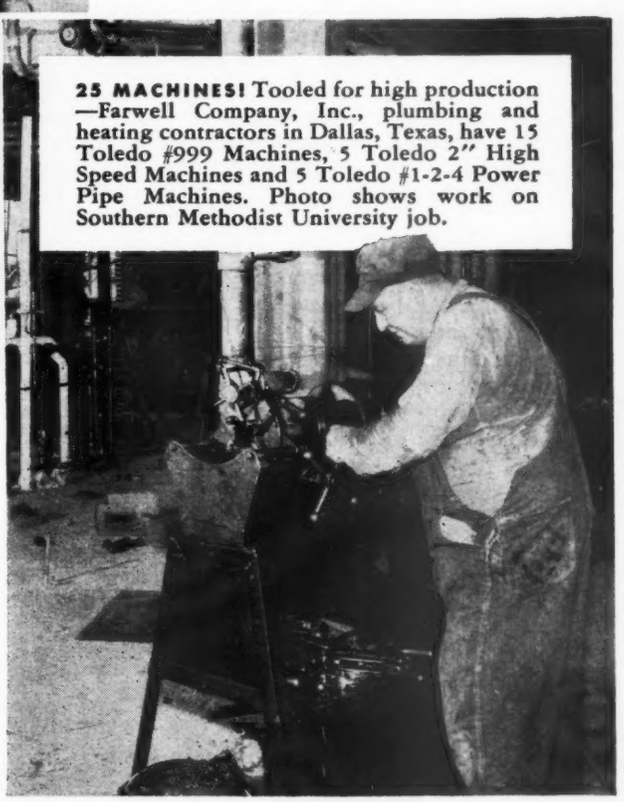
Buckner, Craig and Webster, advertising agency, has announced the opening of a new branch office at 211 Burks Building, Odessa, Texas. The new offices will be under the direction of T. W. (Jack) Womack.

Employees of Enterprise Engine and Machinery Company at the annual meeting in Sanoma Mission Inn, California.

"Long life... Low upkeep!" ...say users of TOLEDO 2" Portable Power Pipe Machines



20 YEARS! "These two Toledo #999 Machines have been in continuous hard service for more than 20 years with only routine service attention," says P. E. Hayes of J. M. Hengy Electric Co., Dallas, Texas. "All our pipe threading tools, both power and hand, are and will be Toledo." Photo taken on Dallas Power and Light Co. job.

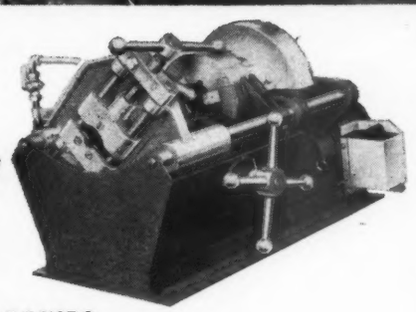


25 MACHINES! Tooled for high production —Farwell Company, Inc., plumbing and heating contractors in Dallas, Texas, have 15 Toledo #999 Machines, 5 Toledo 2" High Speed Machines and 5 Toledo #1-2-4 Power Pipe Machines. Photo shows work on Southern Methodist University job.

Speed Production . . .

It's *5 times faster than hand methods*—this rugged-performing TOLEDO No. 999 2" Power Pipe Machine! Job-proved by thousands of users—progressive outfits like the Texas contractors described above. A machine that's *right* for your high-production needs today!

Threads 2" pipe in 22 seconds . . . cuts off 2" pipe in 10 seconds. Compact . . . portable . . . efficient . . . use it anywhere in your shop, plant or on the job. Your choice—Wheel or Knife Cut-Off. Toledo-built with the know-how of nearly 50 years . . . assuring *long life . . . low upkeep.* Write for catalog. The Toledo Pipe Threading Machine Co., Toledo, Ohio. New York Office: 165 Broadway, Room 1310.



RELY ON THE LEADER **TOLEDO**

PIPE TOOLS...POWER PIPE MACHINES...POWER DRIVES

W. M. Jones, third from left, receives congratulations from J. G. Seiler on the Bethlehem-Tube Turns merger. J. W. Hollingsworth, left, and C. R. Zimmerman, right, look on.

Bethlehem Group Meets To Discuss New Merger

C. R. Zimmerman, executive vice president of Bethlehem Supply Company, Tulsa, Oklahoma, has announced that Bethlehem Supply Company of California will operate as an integral unit of the Tulsa organization. The merger was made public following a recent announcement by John G. Seiler, executive vice president and general sales manager of Tube Turns, Inc., that Bethlehem Supply Company and Bethlehem Supply of California had been appointed authorized distributors of Tube-Turn welding fittings and flanges.

Zimmerman's announcement opened an all-day meeting held in Los Angeles, recently to outline the 1951 campaign for business under the new alliance. Bethlehem of California men present included: W. M. Jones, vice president and general manager; J. W. Hollingsworth, general manager of sales; J. L. McBride, district purchasing agent, and personnel from the company's field stores. Tube Turns, Inc., was represented by Seiler, J. A. Henby, vice president in charge of production; T. H. Pike, Jr., assistant sales manager of the fittings division; J. E. Chumbley, Jr., sales manager of the flange and forgings division; C. B. McLaughlin, manager of engineering service, Gene Wedereit, director of advertising; R. J. Dilger, purchasing agent; L. M. Bound, west coast district manager; E. R. Muir from the San Francisco district office, and N. P. Bosemer, manager of the Los Angeles office.

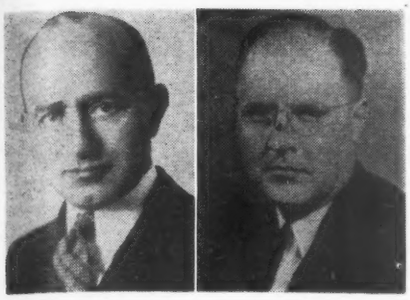
Field Men Study New Weight Indicator

In preparation for marketing Martin-Decker's new Type "F" weight indicator and National Supply's Ideal wire line anchor, several Martin-Decker field engineers recently visited the Martin-Decker plant at Long Beach, California. Attending the intensive instruction course were Martin-Decker factory representatives, Jack Clemens of the Gulf Coast, "Mutt" Donovan of the Mid-Continent, and Carroll Kelso of West Texas. Another Martin-Decker man who visited the plant to study the Type "F" was Sandy Sandhoff, special representative.

Daniel Orifice Expands Houston, Texas, Plant

The Houston, Texas, plant of the Daniel Orifice Fitting Company of Los Angeles, California, has enlarged to take care of necessary production increases. Production capacity has been upped 25 per cent by addition of 5000 sq ft of floor space. A new 2000 sq ft office building was also constructed to take care of the business staff, including sales and distribution personnel. Daniel fabricates orifice fittings for gasoline plants, pipe lines, wind tunnels, and other industrial uses. Other products include calibrated meter runs, meter leveling saddles, piston check valves, and laboratory test apparatus.

Front of Daniel Orifice Fitting's new office building in Houston, with assembled employees.



R. L. Leadbetter D. W. Day

Burgess-Manning Expands

Expansion of facilities of the Burgess-Manning Company, manufacturers of exhaust and air line snubbers and noise abating products, has been announced. The expansion is the result of continued development and increased demand for company products, W. L. Manning, president, stated. He revealed the company is setting up new divisions in Dallas, Texas, and Chicago, Illinois.

R. L. Leadbetter, vice president, has been placed in charge of the Dallas headquarters, established to handle sales, engineering, and development in the petroleum industry, including refining, gas transmission, and the petrochemical fields. He will be assisted by S. G. Paddock as manager of sales, and A. P. Gallagher as engineering assistant.

Dudley W. Day, director of marketing, has been named manager of the new architectural products division. This division includes the company's newly developed radiant ceiling, the Acousti-Booth, and other acoustical products. Assisting Day will be A. C. Kelley, sales, and A. T. Jorn, engineering. C. P. Certik has been named manager of the Libertyville and Ashippun activities, with H. A. Dietrich as manager of sales. The Libertyville plant will continue activities in the industrial and diesel locomotive fields and other company products, Manning said.

New Advertising Agency Formed in Pittsburgh

Effective May 1 an advertising agency to be known as Marsteller, Gebhardt and Reed, Inc., will begin operations, combining the 33-year-old Chicago agency of Gebhardt and Brockson, Inc., and the Pittsburgh, Pennsylvania, office of The McCarty Company. The new company will be headed by E. A. Gebhardt, chairman of the board; Wm. A. Marsteller, president, and R. S. Reed, Jr., executive vice president and manager of the Pittsburgh office.

Other operations of The McCarty Company, pioneer West Coast agency, will not be affected. Likewise, The Marsteller Company, Chicago marketing consultant firm will continue to be situated at 612 North Michigan Avenue, Chicago. Marsteller, Gebhardt and Reed, will maintain offices at 600 South Michigan Avenue, Chicago, and at 600 Grant Street, Pittsburgh.

Other officials of the new agency will include Lewis M. Williams, executive vice president in the Chicago office; Fred B. Livingston, vice president and art director; Harry Neal Baum, vice president; and Lucien M. Brouillette, John R. Burke, George A. Piper, John F. Conners, J. W. Evans, and Ambrose L. Duggan, account executives.

Geophysical Equipment Firm Established

The Radian Instrument Company has established its offices and manufacturing plant at 1707 Cedar Springs Avenue, Dallas, Texas, according to announcement by Cullen R. Rogers, president. Under the trade-name of Rainco, they will engage in the design, manufacture, and sale of geophysical and electronic equipment. Other principal members of the firm are G. L. Hoehn, Jr., vice president in charge of research and development, and Thomas W. Hatch, secretary-treasurer. Alfred L. Sanford and Raymond D. Mallow are the electrical engineers. The Radian Instrument Company was formerly known as the Geotronics Laboratories, Inc., at 5535 Yale, Dallas, Texas.

Royston Sponsors Display Of Pipe Coating Machine

A luncheon was held at the Pittsburgh, Pennsylvania, Athletic Club January 24, for many of the nation's leading utilities and pipe line engineering companies. Following the luncheon guests were taken to the New York State Natural Gas Corporation's Oakford storage pool to observe the new Roskoter line travelling pipe coating machine.

This machine was invented and designed by Allen T. Perry, Compton, California, for the specific purpose of providing a mechanical method to apply Roskote Cold-Applied Pipe Mastics. Basically the Roskoter is the Model "L" cleaning machine with a 21-in. cleaning head, 16 to 18-in. wrapping heads, operating on fiber rollers, and powered by a Continental 226 motor. This machine was designed to spray-coat 20-in. pipe, utilizing 18 spray nozzles to spray-coat effectively Roskote Cold-Applied Pipe Mastic in a uniform film over the entire circumference in one operation. The coating can be applied to the designed thickness by regulating volume sprayed with speed of the machine.

Blaw-Knox Offices Moved

Chemical Plants Division of Blaw-Knox Construction Company has moved its Tulsa, Oklahoma, engineering office to larger quarters at 540 E. Fifth Street to accommodate an increasing volume of engineering and construction work for the natural gas, petroleum, and chemical industries.

R. S. Reed, E. A. Gebhardt, and W. A. Marsteller discuss advertising agency recently organized, of which Gebhardt is president.

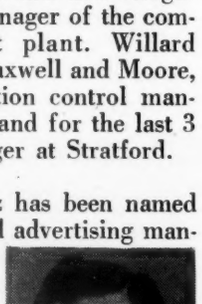
Trade Personals

Henry A. Ruysser, Jr., vice president, has been named general manager of sales of Black, Sivalls and Bryson, Inc. He has been an officer and director of the 55-year-old manufacturer of oil field equipment and steel products for the last 5 years. After two years at Rockhurst College, Ruysser attended the University of Detroit and graduated with a degree in chemical engineering. For a period of years, he was employed in engineering, research and development at the Ford Motor Company.

H. A. Ruysser, Jr.

Robert E. Mason has been appointed director of mobilization planning for the Consolidated-Ashcroft-Hancock division of Manning, Maxwell and Moore, Inc. **Leslie T. Willard** was named works manager of the combined Bridgeport and Stratford, Connecticut, plants. Mason, a former line officer with 30 years of service in the U. S. Navy, joined the company in 1948 upon his retirement from service with the permanent rank of captain, and until this new assignment was works manager of the company's Bridgeport plant. Willard joined Manning, Maxwell and Moore, in 1943 as production control manager at Bridgeport and for the last 3 years, works manager at Stratford.

George Basquez has been named sales promotion and advertising manager by Emsco Derrick and Equipment Company. He took over the post held by the veteran **E. B. "Ernie" Fowks,** when the company moved its advertising and sales promotion offices from Los Angeles to Houston. Basquez has had a varied experience in drilling, production, manufacturing and sales, interrupted by four and one-half years in the army. For four years after leaving the University of Texas, where he majored in geology, Basquez worked for the Shell Oil Company, leaving to enter the service. On his return from overseas he joined the Emsco organization in Houston.



George Basquez

M. F. Hazel, Oil Well Supply Company, has been appointed director of engineering and **Alex Quayle,** chief engineer in charge of all product design. Hazel has served as this U. S. Steel subsidiary's general manager of sales since 1948. Quayle is chief engineer in charge of product design at Imperial Works, Oil City, Pennsylvania, Oil Well's principal manufacturing plant. In his new position he will be stationed at Dallas, Texas.

H. A. Burdorf, vice president of Lunkenheimer, presents Harold L. Layritz with service pin.

Harold H. Layritz, sales manager of The Lunkenheimer Company, valve manufacturers, received his 30-year service pin at a presentation in conjunction with the Cincinnati, Ohio company's annual international sales convention held recently in Cincinnati. Layritz was one of seven Lunkenheimer employees honored for continuous service. **Perry Cooper,** Detroit, and **T. J. McGill,** Pittsburgh, received recognition for 15 years service; **E. F. McAbee,** Baltimore, **R. C. Forbes** and **A. F. Stack,** Boston, and **H. J. Tonkin,** New York, were awarded five-year pins.

Layritz joined Lunkenheimer while still a co-op student at the University of Cincinnati in 1920, and has since worked in sales and advertising.

John Kirby, Byron Jackson Company, has been promoted to district manager for West Texas with headquarters in Odessa, Texas. Well known in the West Texas area, Kirby spent four years with Halliburton Cementing Company and four years with Security Engineering Company before joining Byron Jackson as sales representative in 1947.

C. W. Beauchamp

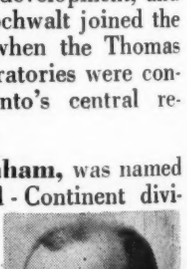
H. M. Bowman

Charles W. Beauchamp, Link-Belt Company, has been appointed assistant sales manager, Ewart, Pennsylvania plant, for both silent and roller chain. **H. Merrill Bowman,** formerly assistant sales manager at the company's Pershing Road plant, Chicago, Illinois, has been named assistant sales manager, Ewart plant, for Ewart general products.

Beauchamp was formerly assistant sales manager silent chain drives at the Ewart plant. Beauchamp was graduated from the University of Cincinnati in mechanical engineering in 1933, whereupon he joined the Link-Belt Dodge plant, Indianapolis. Bowman joined the Philadelphia plant in 1934. After working in the order, engineering, and sales departments, he was transferred to Baltimore, Maryland, in 1940, and became district manager at Baltimore in 1945.

Carroll A. Hochwalt has been elected to a six-man committee of Monsanto Chemical Company, St. Louis, Missouri. He will continue as administrative director of the board of directors and vice president in charge of research, development, and patent activities. Hochwalt joined the company in 1936 when the Thomas and Lochwalt Laboratories were converted into Monsanto's central research laboratories.

G. F. "Bill" Graham, was named sales manager, Mid-Continent division, Pacific Pumps, Inc., to handle Pacific's oil well plunger pump line. Graham's headquarters will be 1221 East First Street, Tulsa, Oklahoma. For the past 17 years Graham has been with the Mid-Continent division of Pacific Pumps and his experience in the industry includes work in the Texas, Arkansas, and Louisiana fields. For the past several years Graham has occupied the post of district manager of Pacific's northern division, including Kansas, Illinois, and the Rocky Mountain fields. The announcement was made by R. A. Dunbar, president.



G. F. Graham

James H. Judge has been appointed sales manager of the Rockwell Manufacturing Company's gasoline, oil, and industrial meter line. Judge became affiliated with the Neptune Meter Company, covering Alabama, Mississippi, and Louisiana in May 1923; Chicago branch manager in 1932, and was promoted to the position of assistant general sales manager in 1945 in New York, a position he held until recently. In his new capacity he will be stationed in Pittsburgh, Pennsylvania.

J. H. Judge

Walter Geist, since May, 1942, president of Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, died suddenly January 29 of a heart ailment. Geist left high school in 1909 to join Allis-Chalmers. After going to work, young Geist took evening and extension courses at the University of Wisconsin in Milwaukee. In his first job at Allis-Chalmers, Geist served as a messenger boy in the blueprint department. Within a short time, he entered the milling department as a tracer, and held the posts of draftsman and engineer before being named assistant manager in 1928; earlier he had developed the V-belt Texrope drive.

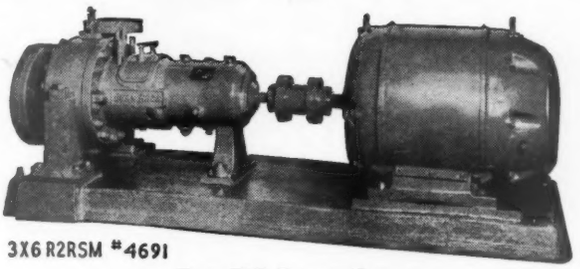
Oliver C. Davis has been made store manager of Continental Supply Company's Artesis, Colorado branch. **Billie R. Riggs** has been made store manager of Brookhaven, Mississippi branch. **G. N. Frost,** former store manager at Brookhaven, has been transferred to Jena, Louisiana, in the same capacity.

Malcolm D. Gilchrist has been elected to the board of directors of Procon Incorporated, a Chicago, Illinois, construction concern serving the petroleum and petro-chemical industry. Gilchrist is well known throughout the petroleum industry for his efforts in acquainting the industry with new refining processes. As well as being familiar with oil refining in this country, he also has acquired experience in foreign refining operations as a result of having spent several years working with refiners in numerous foreign countries.

M. D. Gilchrist

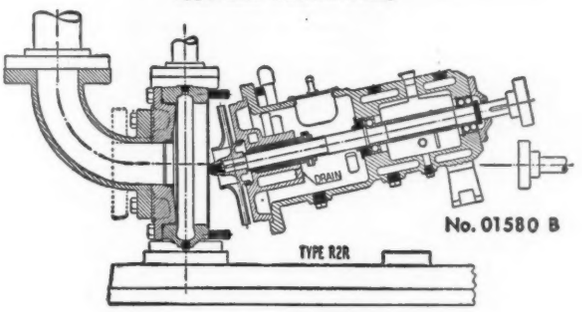
DEAN BROTHERS PUMPS INC.

Type R2R Centrifugal Process Pumps



3X6 R2RSM #4691

Type R2R Process Pump



Type R2R Process Pump

DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE; Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.

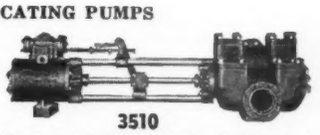
Capacities: 50 to 2000 Gallons per minute. Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL and RECIPROCATING PUMPS

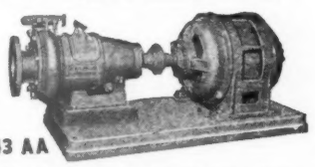
4040H

Close Coupled Centrifugal Pump



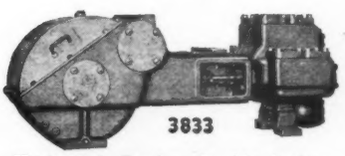
3510

Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids



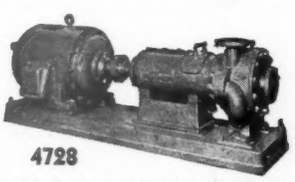
4043 AA

Pedestal Mounted Centrifugal Pump



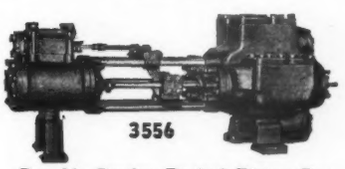
3833

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



4728

Double Pedestal Bearing Centrifugal Pump



3556

Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

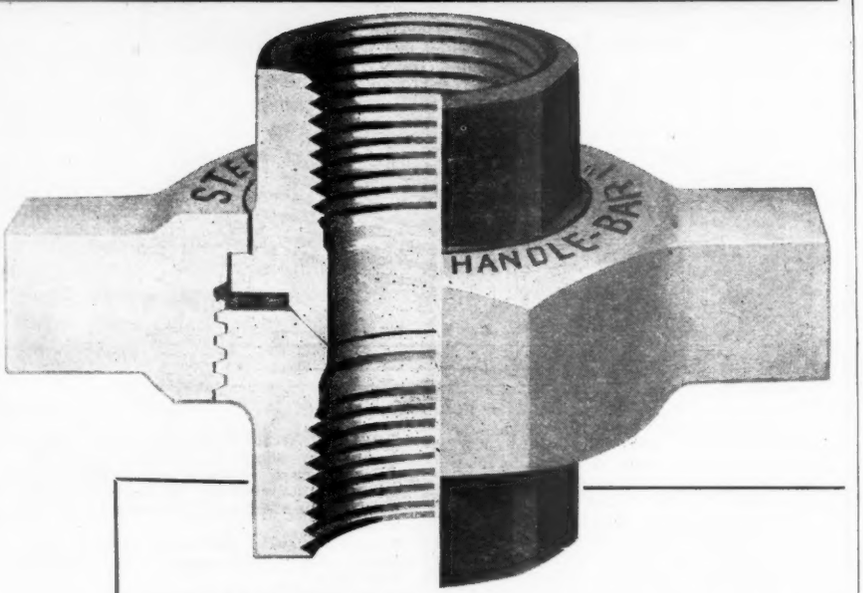
INDIANAPOLIS IND.

323 W TENTH ST.

Branch Offices: NEW YORK, N. Y., HOUSTON, TEXAS

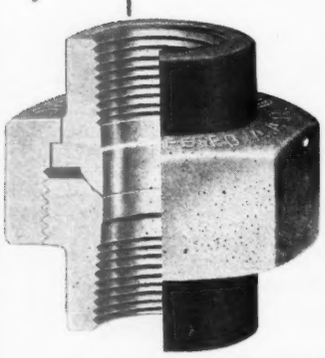
Representatives in Principal Cities

The Boss's Best Friend
HANDLE-BAR
REG. U.S. PAT. OFF.
Forged Steel Unions



HANDLE-BAR 4000 TEST
REG. U. S. PAT. OFF.

Unions are precision made and tested at time of manufacture to assure a tight seal in seats and threads. These famous features are built into each HANDLE-BAR. Integral steel to steel or bronze to bronze seats. Hub ends tapped Briggs Standard steam threads. Nut threads modified Acme. Furnished black hub ends with Udylite nut, or all rust-proof with Udylited hub ends and Parkerized nut. Recommended for all services and on pressures to 3000 lbs.



PETRO A. A. R.
REG. U. S. PAT. OFF.

Unions being precision made and tested on air under oil at the time of manufacture assure a tight seal in seats and threads thereby giving continuous trouble-free performance. Maintenance men that use PETRO Unions know this careful checking and the many features built into PETRO combine to do the JOB obediently.

Write Dept. P for illustrated catalog or refer to listings in Composite Catalog pages 3140-3141, Refinery Catalog page 538, and Chemical Engineering Catalog pages 980-981.

ORDER BY TRADE NAME FROM YOUR LOCAL JOBBER

ORIGINATORS AND PIONEERS OF STEEL UNIONS SINCE 1912

CLAYTON MARK & COMPANY

1900 DEMPSTER STREET • EVANSTON, ILLINOIS

R. K. Laurin

R. A. Fox

▸ **R. K. Laurin** has been appointed assistant advertising manager of the meter and valve division of Rockwell Manufacturing Company by W. F. Weimer, advertising manager. He will be in charge of advertising production and office procedure. Upon graduation from The Pennsylvania State College in 1948 with a degree in journalism, Laurin joined Rockwell Manufacturing Company as a copywriter.

▸ **R. A. Fox** has been appointed manager of the Graver Construction Company, both for all American projects and for all the company's overseas operations. Graver offices in New York, Chicago, Illinois, and Houston, Texas, are under the direction of Fox. His duties also include the supervision of an engineering division in Jersey City, New Jersey. Fox, who formerly served as field assistant to E. B. Heyden, recently deceased head of Graver, is a native of Wichita, and received his mechanical engineering training in Kansas and Texas.

▸ **N. H. Balaam,** Northern California district sales manager of Kaiser Steel Corporation, has been transferred to Washington, D. C., to manage the company's recently-opened offices there. Permanent offices will be established in the Cafritz Building. **C. F. Cooper** has been assigned as acting district sales manager for Northern California.

▸ **Alton F. Davis,** vice president and advertising director of Lincoln Electric Company, has been named industrial advertising's man-of-the-year for 1950 in an annual competition conducted by the magazine, Industrial Marketing. The competition, conducted since 1940 by the publication's "Copy Chasers," nationally known for constructive and occasionally caustic criticism of industrial advertising, is for the purpose of recognizing outstanding advertising published by industry. Davis has been with the arc welding equipment manufacturer since 1914.

A. F. Davis

Howard Pape, vice president of the H. K. Porter Company, Inc., has announced his resignation. Pape joined the Jarecki Manufacturing Company as vice president and director in charge of operations in March, 1945. He transferred the company's headquarters to Houston, Texas, and this company was purchased by the H. K. Porter Company in July, 1949. Jarecki then became a division of the parent company at which time Pape was made a vice president of the H. K. Porter Company.

Lee Laird, Baash-Ross Tool Company, has recently been made California sales manager for the company. Laird has been associated with the oil industry for more than 22 years, having "broken in" to the industry in 1928 with a leading supply company immediately after completing school in Southern California. Six years later he joined the sales staff of the Chicksan Company, which he left, after becoming vice president and general sales manager, to devote full time to his own company, the Gil-Lair Products Corporation. He is a past president and senior regent of the Los Angeles Chapter of NOMADS, as well as secretary-treasurer of the national board of regents of that organization.

Lee Laird

J. Alan MacDonnell has been appointed assistant general sales manager of Gilbert and Barker Manufacturing Company of West Springfield, Massachusetts, makers of gasoline pumps, service station and oil heating equipment, and bulk plant and refinery equipment. In his new post he will assist **Irving C. Jacobs,** vice president and general sales manager, in administering the activities of the four sales divisions of the West Springfield concern. The new appointment fills the place left vacant by the recent retirement of Kenneth S. Edwards. MacDonnell, a graduate of the Massachusetts Institute of Technology, came with Gilbarco in 1934.

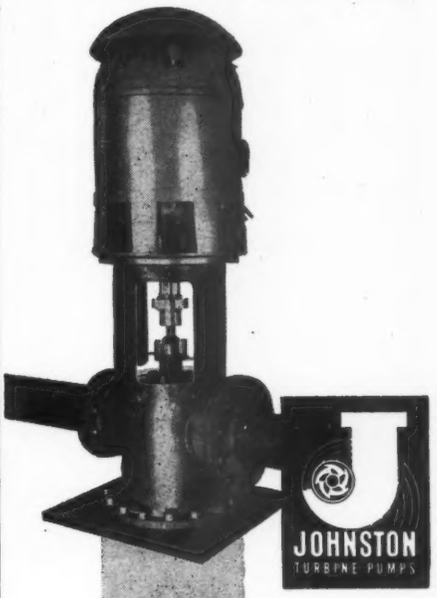
J. A. MacDonnell

L. A. Boyd has been appointed chief engineer for the Born Engineering Company, Tulsa, Oklahoma. Formerly chief engineer of the Texas Natural Gasoline Corporation, Boyd comes to Born with an extensive background in processing, research, design and development. After college, he served in the U. S. Army and in 1917 worked as chemist for the Transcontinental Oil Company. He was, for the past eight years, chief engineer for Warren Petroleum Corporation, in Tulsa, before joining the Born Company early this year.

Introduces New Engines. Present at the press preview party held recently by Lister-Blackstone, Inc., in their New York showrooms to introduce their new air-cooled diesel engines, were: Wilbur Young, general manager, "Diesel Progress"; Walter K. Davies, president, Lister-Blackstone; M. J. O'Leary, editor, "Motorship"; B. D. Fish, chief engineer, Lister-Blackstone; F. Casey, agency executive, La Porte and Austin, Inc. The engine shown is the model AS-2.

No Other Pump Like It!

HEADS TO 1000 FEET!
TEMPERATURES TO 400° F.!
CAPACITIES TO 3000 G.P.M.!



Tough specifications to meet...sure, but the new Johnston Vertical Turbine Pump designed to handle volatile liquids and liquids near the boiling point does it without even breathing hard . . . Proven performance in the refineries of several large oil companies is a matter of record.

This unit, which has the pump bowls enclosed in a sealed steel barrel, takes suction sufficiently above the pump bowls to give the required net positive suction head. The discharge can be at the same level as the suction or higher if necessary. Where there is a limited net positive suction head, such a unit offers many advantages:

1. The supply vessel can be located wherever convenient and the pump bowls then set low enough for proper submergence.
2. Driver and piping connections are at the surface, eliminating dry sumps which are costly to build and expensive to maintain.
3. Nothing to lubricate but driver bearings.
4. Vertical design needs only ⅓ as much valuable floor space.
5. Due to diffuser type construction, this unit has higher efficiencies than conventional centrifugal pumps at high heads.

Technical papers on the Johnston Volatile Liquid Pump are available. Send for as many copies as you need for interested personnel.

JOHNSTON PUMP COMPANY
2324 EAST 49TH STREET
LOS ANGELES 58, CALIFORNIA

EVERY TANK . . . EVERY TIME WITH *Visco*

THE CONSISTENTLY EFFICIENT EMULSION BREAKER

VISCO PRODUCTS COMPANY
INCORPORATED
City National Bank Building
Houston 1, Texas

Call Houston, CAPITOL 7300, collect, for fast action on your emulsion-breaking problems.

Visco

DEHYDRATING AND DESALTING CHEMICALS • WHEREVER COST AND EFFICIENCY COUNT

NOTICE: Visco Products Company is authorized to manufacture and sell Visco Oil Treating Compounds for use in the breaking and resolving of oil emulsions, or to grant licenses for such use, under the following United States Letters Patent: 2,050,639; 2,050,640; 2,206,589; 2,214,783; 2,214,784; 2,225,189; 2,303,414; 2,307,813; 2,318,034; 2,318,035; 2,321,056; 2,335,554; 2,454,808; 2,514,399. Visco Products Company is willing to grant licenses on a royalty basis, to oil companies, and to others desiring to practice the patented subject matter, under any and all of the above Letters Patent, permitting the user to purchase the oil treating compounds at will from any vendor, or to prepare the compounds for use or to use the compounds under the above Letters Patent. Application for license should be made to: **Visco Products Company,** Houston, Texas.

Machinery and Equipment

New! Improved! Needed!

(1) Infrared Spectrometer

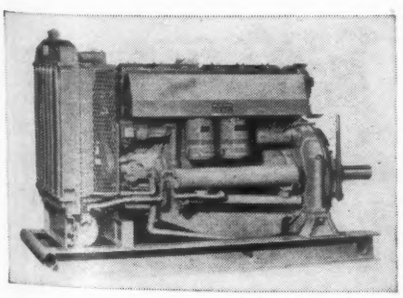
The new mobile Model 12-C infrared spectrometer is now in production at The Perkin - Elmer Corporation, Norwalk, Connecticut. The instrument is particularly suitable for rapid, accurate, on - the - spot analyses of research problems, pilot plant evaluation, or process control. The caster-mounted cabinet and spectrometer literally "take the lab to the problem." The entire unit, measuring 54 by 46 in. by 30 in., passes easily through ordinary industrial doors, and is ready for operation wherever water and electricity are available.

(2) Measurement System

Of wide application is Consolidated Engineering Corporation, Pasadena 4, California's, new recording measurement system, consisting of a carrier amplifier and a recording oscillograph. This provides an extremely flexible method for the measurement of all physical factors involved in successful product performance. Stress, vibration, strain, acceleration, temperature, displacement, pressure, and torque are all measured and recorded simultaneously during the same operating cycle and are analyzed as functions of one another.

(3) Diesel Engines

A new line of heavy duty diesel engines has recently been announced by the Murphy Diesel Company, Milwaukee, Wisconsin. The new line, consisting of six models from 145 hp to 220 hp, is designed to operate at continuous speeds up to 1400 rpm. This higher operating speed will make possible the application of Murphy diesels in many new services including those requiring torque converter power transmission.



(4) Loading Cylinder

To simulate the effects of forces developed by the expansion and contraction of pipe lines on their gate valves in field service, the W-K-M Company, Houston, Texas, has designed a huge fixture with a built-in two-way hydraulic loading cylinder capable of applying tension and compression up to 1,000,000 lb on valves as large as 30 in. or more. The operation of the gate and valve stem was observed and the leak resistance of the valve was checked under load. Tests were made under external loads of 675,000 lb with and without internal hydraulic pressure of 850 psi. Equipment used in the test set-up included short lengths of 30-in. pipe, which were welded on the valve flanges. Pressure connections were made at the left end. Fluid pressure was supplied by a triplex pump.

(5) Arc Welder

A special 300 amp gasoline engine driven arc welder with a 3 kw auxiliary power generator, is being announced by the Hobart Brothers Company, Troy, Ohio. This arc welder and power generator is a self-contained unit, powered by a 6-cylinder self starting Chrysler industrial engine directly connected to the welding generator and mounted on a welded steel frame. An auxiliary 3 kw power generator provides for lights and such tools as a lathe, grinders, drills, brake reliner, valve refacer, chipping hammers, power wrenches, and paint sprayers. The unit is completely enclosed by a sheet metal canopy that is bolted directly to the frame. The engine is a Chrysler 6 cylinder, 4 cycle, 1500 rpm, water-cooled engine developing about 53.5 hp at 1500 rpm and connected to the welding generator.

These are very brief descriptions of new items manufacturers have put on the market but you need more information to appreciate advance in design, materials, performance, etc. Send the coupon below for details.

Get Full Details of March, 1951, Listing — Circle Figures and Mail Coupon to

THE PETROLEUM ENGINEER

P. O. Box 1589, Dallas, Texas

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
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NAME..... TITLE.....

COMPANY NAME.....

STREET ADDRESS.....

CITY..... ZONE NO..... STATE.....

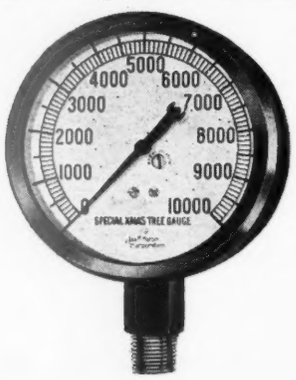
(6) Fire Extinguishers

American-LaFrance-Foamite Corporation, Elmira, New York, announces a new pressurized, one-quart fire extinguisher, which, it states, aims like a gun. It is compressed air

expelled and requires no hand pumping. It can be operated with one hand and is easily recharged and can be readily pressurized with any standard air chuck exerting 150 psi; such as commonly used in gasoline service stations. It is for class B and C fires in motors, autos, aircraft, trucks, trailers, buses, motor boats, electrical equipment and all other risks involving small oil and grease fires.

(7) Pressure Gages

A new pressure gage, specifically designed for use on christmas trees, has been announced by Marsh Instrument Company, sales affiliate of James P. Marsh Corporation, Skokie, Illi-



nois. An important basic innovation in the construction of the gage is a new method of joining the bourdon tube to the socket of the gage and joining the end-piece to the bourdon tube. By a new process, the bourdon tube is Conowelded into the socket and to the end-piece to form the equivalent of one-piece construction. In this way the unit that has always been most difficult to keep leak-tight is permanently sealed. The new tube is to be known as the "Conoweld" tube.

(8) Bearings

Boston Gear Works, Quincy, Massachusetts, presents a new line of porous bronze bearings, cored bar, solid bar, and plate stock in a wide range of stock and sizes in stock for immediate availability. The new Bost-Bronz bearings carry their own oil reservoir providing an oil film that is always present on every surface. This not only adds to the wearing quality of the bearing but actually increases its load carrying capacity as the shaft always rests on an oil cushion even when at rest. Bost-Bronz is re-lubricated by applying oil to the outer surface. The oil is absorbed by capillary attraction. Dirt is repelled by the bearing and there are no holes or grooves to permit entrance of grit, lint, or dust. Bost-Bronz bearings are easily assembled with any reasonable press fit and will not break or chip.

(9) Pipe Line Coupling

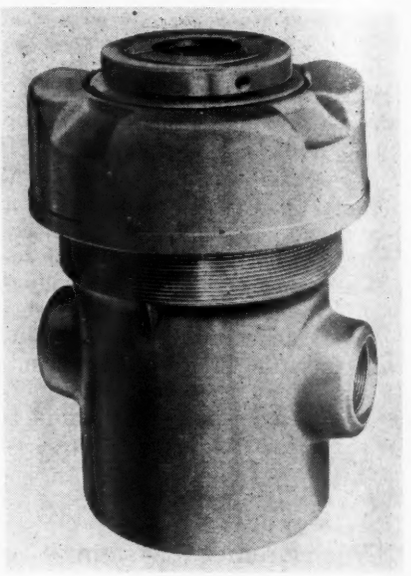
The new Weld + Ends coupling for the rejoining of crude oil, gasoline, L P gas and gas pipe lines is now available from The E. H. Wachs Company, Chicago, Illinois. Special design and construction pemits the effective sealing of pipe from 2 to 36 in. in diameter in a matter of minutes. Full pipe line pressure can be restored immediately and welding done after line is back in service saving costly down time and cutting product losses and labor costs. The safety feature of the Weld + Ends coupling makes it possible to rejoin high pressure steel pipe lines under hazardous conditions without using a torch due to the use of a mechanical seal.

(10) Corrosion Control

American Sand-Banum Company, Inc., New York, New York, has developed a new corrosion and rust control paste called Tinallium Pro-Tex-It. It is in the form of a non-drying black paste, and according to company engineers, has a great area coverage, depending on degree of smoothness of surface to which applied. It is adaptable for all metals, woods, and concrete mixes for preservation against weathering conditions, acids, fumes, chemicals, etc. It constitutes protection against alkali, rust, corrosion, oxidation, heat, cold, steam, gas or sulfur fumes, brine and other destructive agencies either above or below ground. The paste will not stain water or other liquids and will withstand contraction and expansion. It is fire-resistant and water repellent. It contains no lead oils, graphite, creosote, or tar and stops decay, rust, or rot, and it is non-poisonous.

(11) Tubing Head

To satisfy the need for a low pressure tubing head for both flowing and pumping wells, The National Supply Company, Toledo, Ohio, has introduced the new Type "E" tubing head.



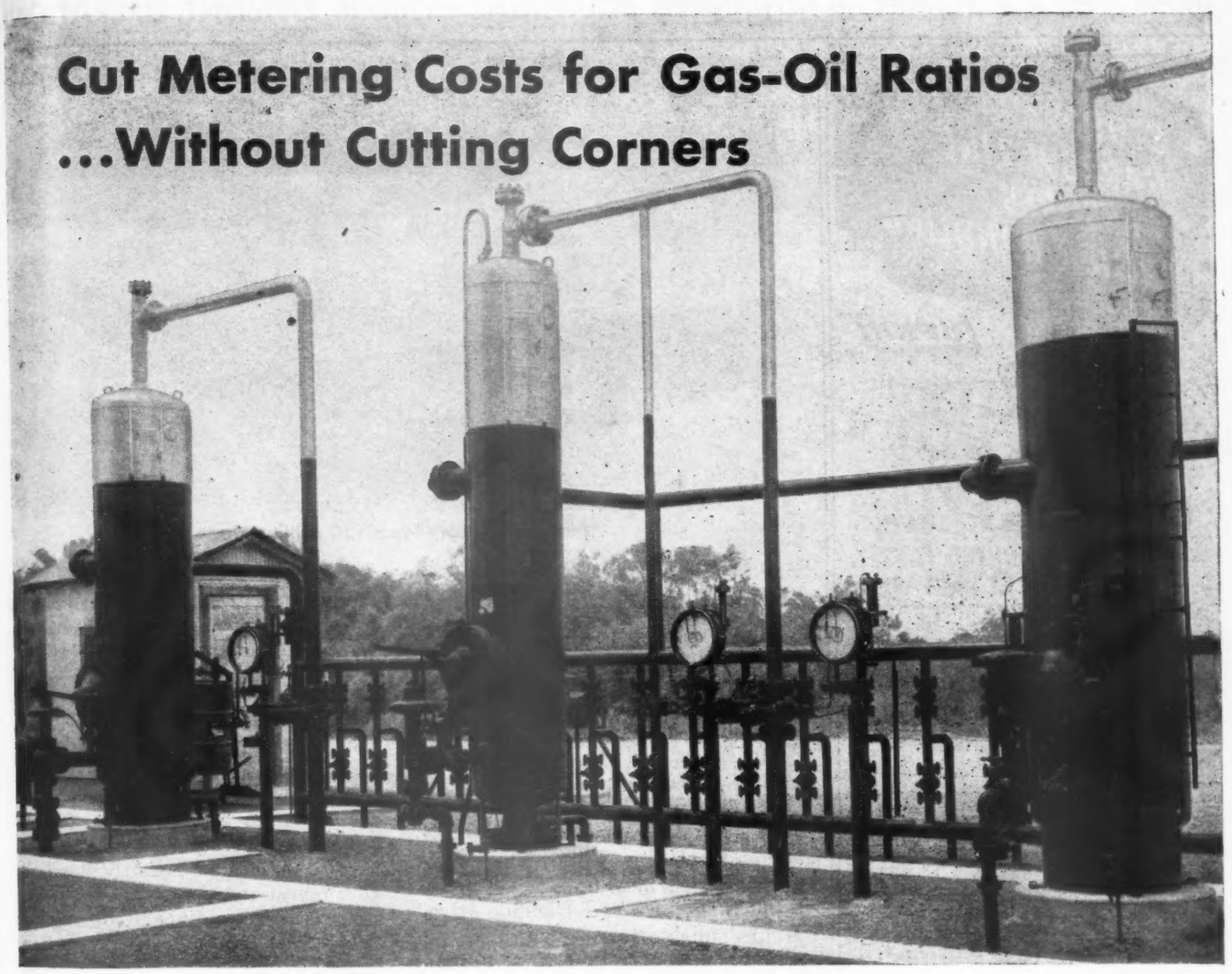
The Type "E" has a working pressure of 2000 psi and a depth rating of 10,000 ft. It has a full opening body that is provided with either flanged or screwed bottom connections for 7-in. and smaller casings. Blowout preventer equipment may be readily applied to the Type "E" tubing head as it has an 8⅝-in. male casing thread to which a broad flat cap is attached.

(12) Rotary Seals

The Garlock Packing Company, Palmyra, New York announces a complete line of rotary seals, to be used where leakless operation of a rotary shaft on a pump or other equipment is required. Sealing is effected by leakless and positive contact between carefully lapped metal-

to-carbon or metal-to-metal mating surfaces. One of these elements rotates with the shaft and the other is stationary. The stationary element does not contact the shaft. If none of the standard designs appears entirely suitable for any specific application, a modification of a standard design or a specially designed seal will be engineered and built for that job, the company stated.

Cut Metering Costs for Gas-Oil Ratios ...Without Cutting Corners



Measuring gas from Separator Batteries at Conoco Driscol Field, Benavides, Texas with 3 Foxboro Gas Flow Meters Type 4.

HERE'S THE WAY IT'S DONE

By taking advantage of the exclusive features built into Foxboro Flow Meters, you can cut meter inspection trips and recalibration to the bone . . . *and eliminate mercury losses completely.* You won't need to coddle these meters to get accurate records.

Foxboro Flow Meters are designed with a *unique straight-line linkage* that makes factory adjustments permanent. Their sustained accuracy is outstanding. Four to six years' service without recalibration isn't uncommon! In addition, floats of Foxboro Meters are *extra large* and have *extra long* travel. This means unequalled *power* . . . giving highest accuracy at the pen. *Sure-Seal Check Valves,* submerged in mercury, positively prevent mercury losses. And for freedom from friction and freeze-ups, Foxboro Pressur-Tite Bearings have never been equalled!

These are the reasons why experienced production men prefer Foxboro Flow Meters above all others . . . why *you* can cut metering costs without jeopardizing the accuracy of your records.

WRITE FOR Bulletin 351-2 for complete details.

The Foxboro Company, 1303 Neponset Avenue, Foxboro, Mass., U.S.A.

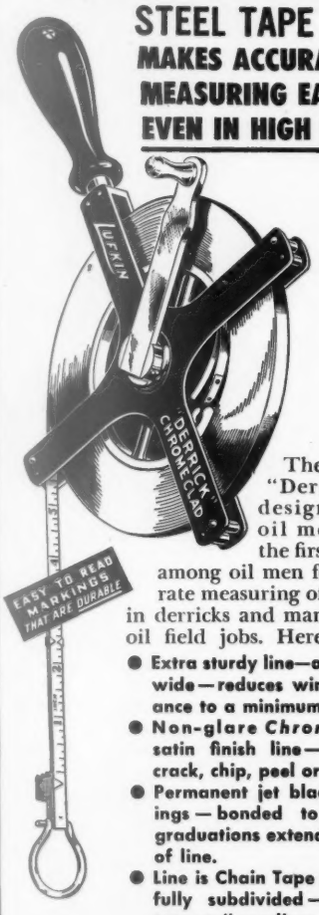
FOXBORO
REG. U. S. PAT. OFF.

MONEY-SAVING FLOW METERS

STURDY NARROW LINE ASSURES EASIER HANDLING

LUFKIN

"DERRICK"
CHROME-CLAD
STEEL TAPE
MAKES ACCURATE MEASURING EASY... EVEN IN HIGH WIND

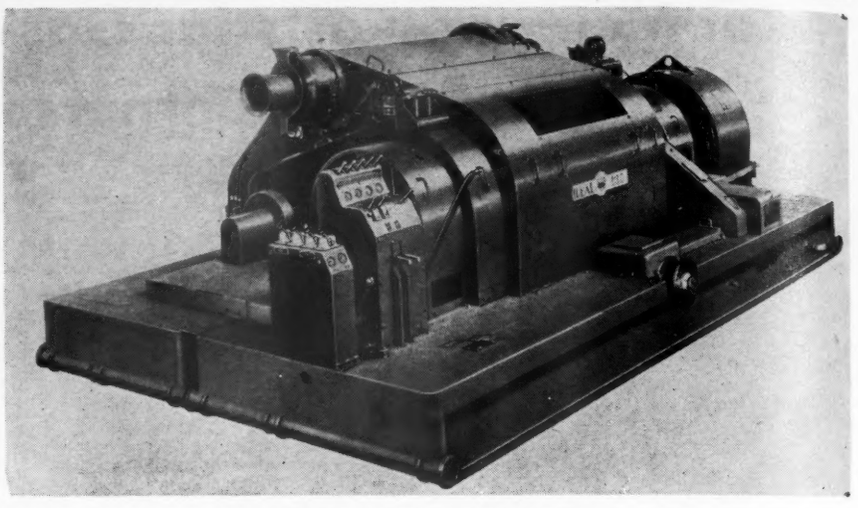


The *Lufkin* "Derrick" — designed by oil men — is the first choice among oil men for accurate measuring of casings in derricks and many other oil field jobs. Here's why:

- **Extra sturdy line—only ¼-in. wide—reduces wind resistance to a minimum.**
- **Non-glare *Chrome-Clad* satin finish line—will not crack, chip, peel or corrode.**
- **Permanent jet black markings—bonded to steel—graduations extend to edge of line.**
- **Line is Chain Tape weight—fully subdivided—"Instantaneous" readings.**
- **Oversize drum increases winding speed. Long handle gives extra leverage—line locking type.**
- **Substantial, 4-arm frame has tape roller in each arm. Tape removable from frame.**
- **Improved pattern finger rings. Patented reinforcing strip prevents kinking and first end breakage.**
- **Hook is securely riveted to lip of detachable, swinging ring.**

In 100-ft., 150-ft. and 200-ft. lengths marked feet, 10ths and 100ths; or feet, inches and 8ths. See them at your Supply House. 87

Buy LUFKIN
TAPES • RULES • PRECISION TOOLS
THE LUFKIN RULE CO.
SAGINAW, MICH. • New York City • Barrie, Ont.



National Supply Type 130 drilling rig.

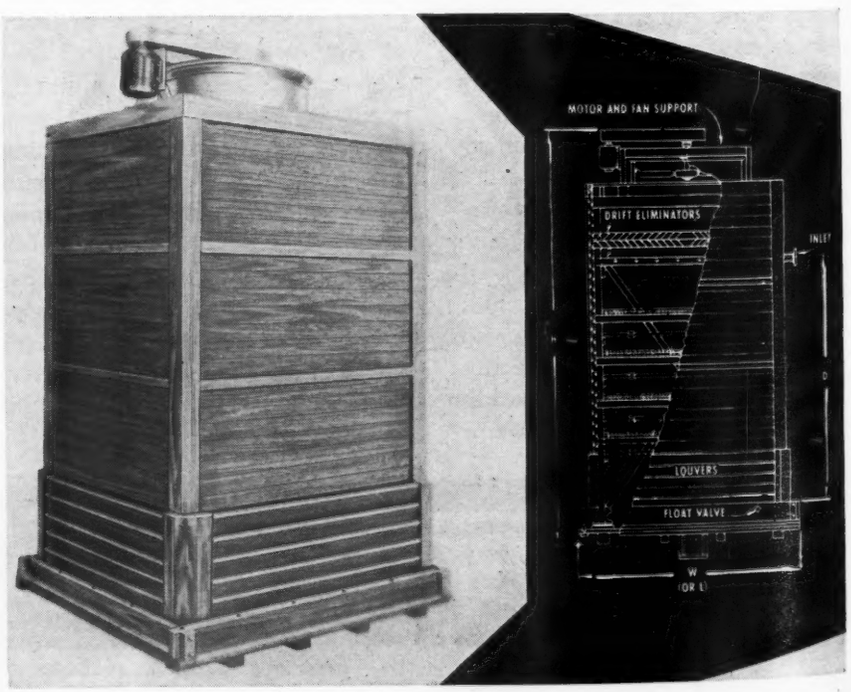
(13) Drilling Rig

National Supply Company, Toledo, Ohio, announces a new drilling rig known as the Ideal Type 130 consolidated rig. It is normally considered for drilling in the 12,000 to 15,000 ft depth range, and the first Type 130 rig was placed in service by The Texas Company. Included in the rig is a new draw works designated as the Type 130 and an Ideal Type "B" sectional drive group, which may be selected from a full range of 3 and 4 engine drive groups suitable for use with 6 or 8-cylinder engines in the 300 to 400 hp class. The new Type 130 draw works is rated at 1300 input horsepower. It provides 6 forward hoisting speeds, 3 rotary speeds, and 3 catshaft speeds. Two reverse speeds are provided for the hoisting drum, one reverse speed for the rotary machine, and one reverse speed to the catshaft.

(14) Cooling Unit

The Santa Fe Tank and Tower Company of Los Angeles, California, has standardized production of the new Econotower, a compact water cooling tower designed for efficient, economical operation. As the performance of these units is fairly standard in application, Santa Fe engineers have designed and are producing the Econotower on a mass production scale. The Santa Fe Econotower is built in 3 distinctly different types: (1) horizontal flow, (2) vertical flow, (3) cylindrical vertical flow. Towers are completely prefabricated, and ready for rapid erection.

Santa Fe Tank and Tower's new water cooling tower.



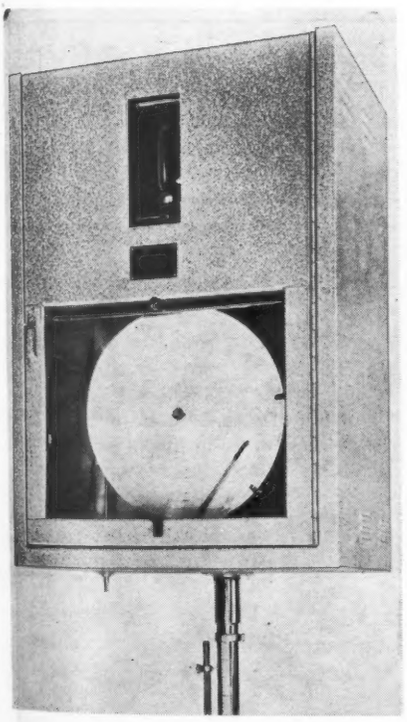
(15) Fluorimeter

A new instrument for research and routine work has been developed by Cenco in collaboration with Dr. Theodore E. Friedemann* and George S. Liebeck†. It is a photoelectric fluorimeter designed primarily for all types of fluorimetric analysis and useful in colorimetry and nephelometry. The new instrument has linear sensitivity over a wide range in which the relative sensitivity is changed by means of a dial switch that expands the meter readings to 1, 2, 5, 10, 20, 50, and 100. It also has a high sensitivity to permit the assay of microquantities even though optical filters may be used.

*Northwestern University Medical School.
†American Telephone and Telegraph Company.

(16) Gas Gravitometer

The American Recording Chart Company, Los Angeles, California, has made available a gas gravitometer for corrosive service. All parts of the meter that come in contact with the sample are made of stainless steel. This new development applies to both the standard instrument and the "Dry Air" type. In cases where corrosive



gases are not encountered, the standard line of ARCCO - ANUBIS gas gravitometers is available. These instruments, for corrosive and non-corrosive gases, are made in two standard ranges, one a .5 specific gravity using 150 cm. column in which case the range may cover .5 to 1.0; .7 to 1.2; and 1.0 to 1.5. The other is a 1.0 specific gravity range using a 75 cm. column. The range would cover from 0 to 1.0; .5 to 1.5, and 1.0 to 2.0.

(17) Geared Motors

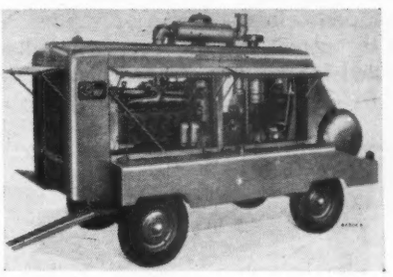
Sterling Electric Motors, Inc. of Los Angeles, California, is currently introducing a new improvement on its "Slo-Speed" geared motors. This new type geared motor is of the single reduction, "Klosd-Tite" construction for atmospheres containing non-explosive dusts, vapors, and injurious foreign materials. An external fan forces powerful cooling blasts of air over the streamlined case. Output shaft ratings are the 6 AGMA speeds starting at 780 rpm down to and including 280 rpm. This new Sterling "Slo-Speed" "Klosd-Tite" motor, type FWFA, is totally enclosed and includes such Sterling features as labyrinth seals, liberal heavy duty ball bearings lubricated for life, and many others.

(18) Pipe-Casing Protector

Tuboscope Company of Houston, Texas, is currently introducing Tube-tector, a laminated drill pipe-casing rubber protector, to the drilling industry. Tube-tectors feature greater gripping strength and more effective gripping area due to laminated construction and especially developed oil-resistant rubber. Tube-tectors grip the pipe with a pressure of over 1000 psi. This pressure minimizes the possibility of movement on the pipe and reduces ring cutting and the possibility of losing protectors in the hole. Protectors are placed directly on the pipe, without the use of transfer sleeves, as pipe is being run in the hole.

(19) Air Compressor

A sensationally new type of large size portable air compressor has been announced by Ingersoll-Rand Company, Phillipsburg, New Jersey. It features a rotary type compressor. The unit is designated as the Gyro-Flow



600. It delivers 600 actual cubic feet per minute free air at 100 psi. Total weight is only 9500 lb ready for use. Major advantages claimed by the manufacturer are simplicity and low cost of operation and maintenance, greater reliability, lighter weight, and a discharge temperature at least 100 F lower than that of conventional portables. The compressor itself is an advanced-design, two-stage, oil-cooled rotating-vane compressor.

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(20) Tape

Labelon Tape Company, Inc., Rochester 7, New York, has announced a new type tape usable in industrial application. Labelon tape sticks firmly without moistening. It adheres well to metal, plastics, paper, or any other smooth surfaced material — painted or otherwise. It consists of a special writing surface sandwiched between two layers of acetate. It will not yellow with age, or dry out and curl, the company claims. It can be written on with pencil, stylus, or typewriter. Fixed in its own dispenser, the tape is 5/8, 3/4, 1, or 1½ in. wide.

(21) Screw Pump

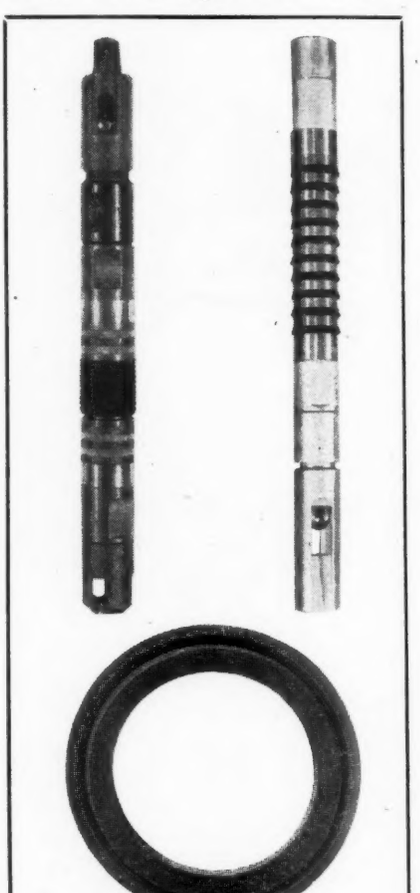
A new external gear and bearing bracket type screw pump for positive displacement of non-lubricating liquids of all viscosities at 1 to 700 gpm, is announced by the Sier-Bath Gear and Pump Company, Inc., North Bergen, New Jersey. One of the features of the pump is the new single point alignment. The external timing gears and all bearings are in housings, which form an integral unit with the pump body. Thus there can be no strain on bearings, or misalignment of shafts or rotors. New rotors give less wear on bearing and timing gears.

(22) Rotary Hose

United States Rubber Company, Rockefeller Center, New York, has developed a new wire reinforced rubber and fabric rotary hose for high pressure oil well drilling operations. Wire reinforcement together with fabric and rubber construction gives the hose the strength to withstand the pressures of the heaviest pumps in the oil fields, while retaining flexibility and kink resistance, the company said. The new hose will drill a well from top to bottom regardless of pump pressure required or gas pressure encountered.

(23) Pump Cups

Wilson Supply Company, Houston, Texas, has developed a "No-Friction" sub-surface pump cup. These new cups are made from a special synthetic rubber compound that is highly resistant to all abrasives as well as chemical attack from oil and salt water brines. Due to the patented design of the pump cups their lips are free to flex with alternating loads. Because of their increased wiping action sand does not pass them and the working barrel tube is wiped clean on each



stroke of the pump. The cups are supplied in all standard sizes and recommended for both tubing and rod type pumps.

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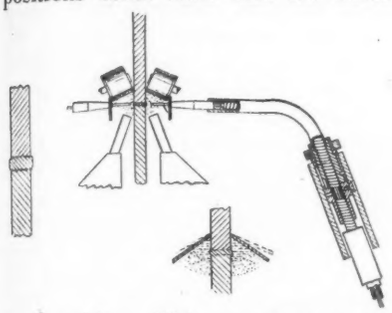
(24) New Welding Process

A new process, developed and patented by The Lincoln Electric Company, Cleveland, Ohio, extends the advantages of automatic hidden arc welding to jobs where the joint is in positions other than that for down-



hand welding. This new process consists of new welding methods, procedures, and equipment wherein the previous difficulties of directing the electrode and retaining flux and molten metal in a joint not lying flat are overcome. With this process the plate being welded may be positioned anywhere from flat to vertical, the joint being horizontal. The new process is referred to as "3 o'clock" welding. Welds from both sides of the joint can be made simultaneously.

(25) Insert Pump

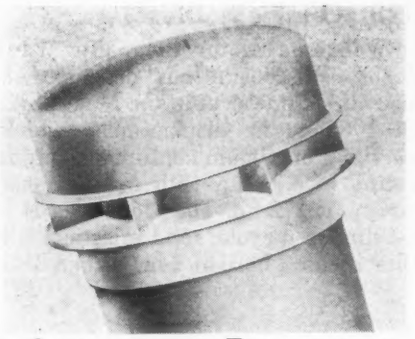
A new insert pump, designed to handle abrasive, or sandy production, and for wells having high sub-surface formation temperatures, has been marketed by Harbison-Fischer Manufacturing Company, Fort Worth, Texas. The pump has two concentric, reciprocating tubes that telescope over and in a third tube that serves as the pump barrel. The metal plunger is loose-fitting and free-falling in the barrel tube to provide ample clearance for sand and scale particles. The resulting fluid slippage is diverted to the small annular space formed by the outer tube and acts as an automatic fluid-seal and packing medium.

(26) Hand Serrating Tool

National Carbon Division, Union Carbide and Carbon Corporation, New York, New York, now has available a hand serrating tool for use with "Karbate" brand impervious graphite pipe. As Type FC flexible couplings are used in fitting impervious graphite pipe, the effectiveness of the joint depends to a considerable extent upon the quality of the serrations on the pipe. The tool is simple, and easy to use, assuring a tight joint in a minimum of time. It provides an advantage over other types of piping since it facilitates quick assembly of "Karbate" pipe on the job site. Pipe sizes from 1 to 6 in. may be serrated.

(27) Draft Caps

Tesco, Inc., Tulsa, Oklahoma, has developed a new type draft cap, the important feature of which is the fuel savings that result from the balancing principle employed. The new Blu-Blaze Type E vent cap almost completely eliminates the effect of draft, the company said. The harder the wind blows across the top of an open pipe, the more heat it sucks out, and balancing this effect would therefore reduce fuel consumption. Savings up to 20 per cent over a long period of time were noted by Tesco engineers. Draft caps will press tight onto any standard type of round vent pipe with



moderate pressure. Tests were conducted with houses whose gas consumption records were available both before and after, in comparison with houses where caps were not used.

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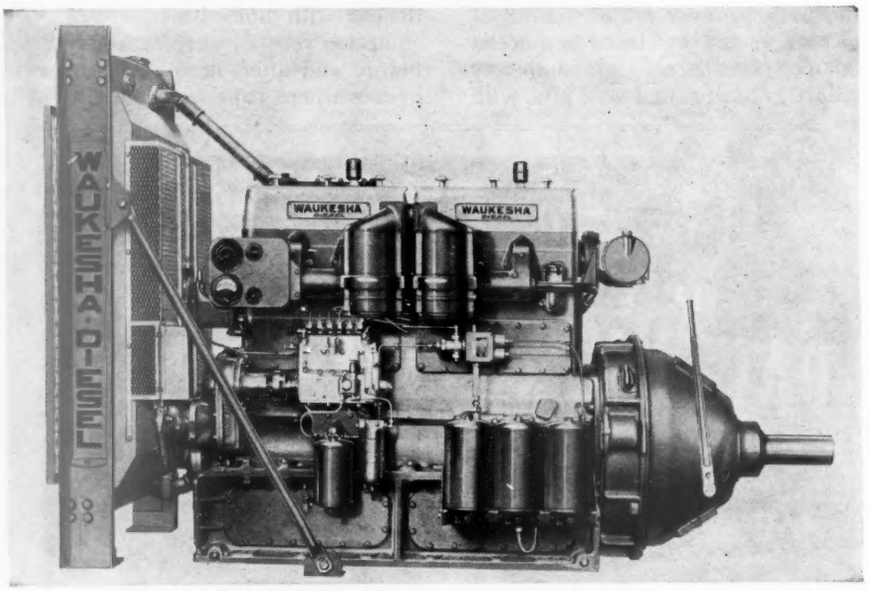
(28) Oil Field Diesel

Waukesha Motor Company, Waukesha, Wisconsin, has developed a new diesel power unit, the Mogul Six, of 1905 cu in. displacement, which carries a maximum continuous output rating of 201 hp with overload capacity of 272 hp. The Mogul Six is a 6-cylinder, 4-cycle, solid injection full diesel with a bore of 7-in., stroke 8¼-in., and displacement of 1905 cu in. Some of the features that the makers claim, make this an outstanding engine for the oil industry are its massive alloy steel, 7-bearing crankshaft with vibration dampner and hardened journals and crankpins; its hardened wet sleeve cylinders; oil-jet piston cooling and aluminum alloy pistons, full floating piston pins, etc.

New diesel power unit developed by Waukesha.



(29) Electronic Recorder

An electronic recorder for measuring temperature of the rotor in large electric generators has been developed by Minneapolis-Honeywell Regulator Company, Philadelphia, Pennsylvania. The ElectroniK has been designed to assist operators in avoiding overloads, according to Charles W. Bowden, central stations industry manager of the company's Brown Instruments division. In addition, the instrument supplies a 12-in. strip chart record that can be used as a guide for gradually cooling a generator. The recorder has a range of 0 to 150 C, a limit error of 1.5 C, a dead zone of 0.3 C, and a pen speed of 1.4 min full scale.

(30) Breather Valve

A new vacuum - pressure breather valve for bulk tanks has been announced by Shand and Jurs Company, Berkeley, California, petroleum equipment manufacturers. The new corrosion resistant breather valve pallets and pallet seats are of thermosetting molded phenolic. The cover for both the vacuum and pressure valves is cast in one single unit. It is attached to the valve body by a swinging yoke that mounts a thumb screw that tightens down againt the cover holding it in place.

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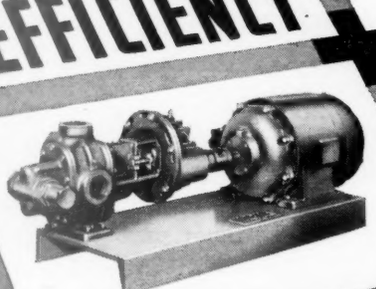

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(31) Machinery Bulletin

All types of machinery manufactured by the company are contained in a new 28-page two color bulletin published by Nordberg Manufacturing Company, Milwaukee 7, Wisconsin. Fully illustrated with installation and product photographs, this booklet also gives design data on Nordberg two and four-cycle stationary and marine diesel engines, gasoline marine engines, Symons cone crushers and screens, mine hoists, machinery for the basic processing of ores and minerals, air and gas compressors and railway track equipment.

(32) Ball Joints

"Flexible Ball Joints" is the title of a new 16-page bulletin that has just been published by Barco Manufacturing Company, Chicago, Illinois, maker of flexible ball, swing, swivel, revolving, and other types of movable joints for use in piping for power, process, heating, chemical, or hydraulic service. The Barco ball joint consists of a short pipe nipple terminating in an enlarged hemispherical section or ball that is housed inside an outer casing between two molded gaskets.

(33) Mechanical Tubing

The Babcock and Wilcox Tube Company, Beaver Falls, Pennsylvania, announces the latest edition of a table on tolerances for round seamless carbon and alloy steel mechanical tubing, giving permissible variations in diameter and wall thickness. It refers to cold-drawn-unannealed and finished-annealed tubing in sizes to 8⅞ in. OD, and to hot-finished tubing in sizes to 9⅝ in. OD.

(34) Drilling Bits, Jars

Acme Fishing Tool Company, Parkersburg, West Virginia, has issued a 4-page bulletin on its drilling bits and drilling jars. The Acme alloy "Drilmor" bits were developed to cut hardest formations. They can be field-dressed and properly tempered without special equipment, in the same way proper dressing of regular carbon steel bits can be applied. Acme's drilling jars are also made of alloy steel. Other features are pyrometer controlled heat-treated, for balanced tensile strength and hardness, insuring longer wear and maximum footage.

(35) Display Train

A new bulletin featuring its electrical equipment display train, which is touring the country, has been published by General Electric Company, Schenectady, New York. The displays include the latest electric equipment, techniques, and ideas for progress on board the More Power to America Special. New equipment for producing, distributing, and using electric power more efficiently and profitably has been assembled in one series of related exhibits—filling nine cars of the display train. Other displays include, turbines of all types, equipment for transmitting and distributing electric power, motors and controls engineered into combinations capable of performing a tremendous variety of industrial operations.

(36) Oil Filter

An oil filter is not an oil refinery, according to a new 16 page informational booklet published by Caterpillar Tractor Company, Peoria 8, Illinois. Entitled "Don't Buy Trouble," it deals with oil filters, their purpose, their makeup, and the qualities to be looked for in a filter. The booklet begins by giving a brief history of lubrication, beginning with its application to wooden wheels and axles. It notes that the invention of the engine, with its increasing speeds and frictions and resultant heat increases, required that oil be saved and recirculated. And with recirculation came the problem of getting rid of the destructive elements the oil had picked up during its trips through the engine. The booklet then outlines a number of tests Caterpillar Tractor has made on oil filters, and shows why they use the type filter they do.

(37) Crane-Excavators

A new 14-page catalog, illustrating in color the heavy-duty lines of Wayne Crane ½-yd crane-excavators, has been published by Wayne Crane division, American Steel Dredge Company, Inc., Fort Wayne, Indiana. Numerous features of all three Wayne Crane models—crawler, truck, and wagon—are shown in this descriptive catalog. These include the new deck machinery layout, self-leveling chassis, oversize 20 in. clutches, large modern cab, and right angle drive mechanism. The newly completed line of ½-yd excavators has lifting capacities ranging from 8 to 12½ tons. Gasoline or diesel power is optional.

(38) Drilling, Truck Tools

Catalog No. 51, published by LeBus Rotary Tool Works, Longview, Texas, lists complete information on its rotary drilling and truck tools manufactured. This catalog also lists data on the LeBus drop forge plant and includes a directory of sales representatives and service installation shops.

(39) Moisture Meter

The TAG midget moisture meter, specially designed for instantly determining the moisture content of wood, lumber, plaster and wood products, is described in a new six-page bulletin issued by the Tagliabue Instrument Division, Weston Electrical Instrument Corporation, Newark 5, New Jersey. Fast, accurate, self-contained, and compact, the TAG midget moisture meter, as described in the bulletin, measures moisture by the electrical resistance method originally introduced by TAG for determination of moisture content of wood. Readings are taken directly at the touch of a button in per cent moisture.

(40) Hydraulic Controls

"Caterpillar Hydraulic Controls" is the title of an eight-page booklet recently published by Caterpillar Tractor Company, Peoria, Illinois. Illustrated booklet explains in detail how the three models of hydraulic controls fit the various models of Caterpillar track-type tractors. Arrangements needed to adapt the versatile No. 44 hydraulic control to either the D2, D4, or D6 tractors are itemized in tabular form. Complete specifications for all three controls are included. Pictorial cutaways show the detailed construction and operating features of the controls and the hydraulic jacks. An explanation of "hydraulic balance" in the vane type pump shows why the feature is so important to long and trouble-free pump life.

(41) Oil Well Shooting

Use of nitroglycerin in blasting oil loose from the earth, type of equipment in use today as compared with the type previously used, and other pertinent facts on oil well shooting is fully explained and illustrated in a new 12-page multicolored booklet, published by Independent-Eastern Torpedo Company, Tulsa, Oklahoma. This publication shows a cross section of the type of bombs used in shooting as well as a colorfully illustrated complete picture of the bomb in action. The booklet also contains a directory of shooting service stations, acid service stations, nitroglycerin factories, and division headquarters.

(42) Lightweight Additive

A new folder on Strata-Seal, two color, 4 pages, 8½ by 11, is now available, from Great Lakes Carbon Corporation, Long Beach 5, California.

Strata-Seal, a lightweight additive to combat and prevent lost circulation of drilling mud, has just recently been made available to the oil industry by Great Lakes Carbon. The folder gives two examples showing actual savings through the use of Strata-Seal. Several actual Strata-Seal well histories are also included. One whole section is devoted to the subject "What is Strata-Seal?" while another short section is devoted to recommended uses.

(43) Radiators

Young Radiator Company, Racine, Wisconsin, and Mattoon, Illinois, has just announced the completion of a new Catalog No. 1651 covering its line of Mono-Weld radiators. The 4-page, 2-color piece shows the design features and accessories for both the one-piece and sectional-type cores. One-piece Mono-Weld radiators are available in various sizes capable of dissipating from 70,000 to 800,000 Btu per hour under standard conditions. The sectional-type core units are of larger size ranging in capacity from 960,000 to 3,250,000 Btu per hour. Core sizes range from 2½ to 10½ ft sq.

(44) Communication

Three new brochures describing RCA's latest station equipment for two-way mobile radio communication systems are now available from RCA Engineering Products Department, Camden, New Jersey, the company announced. Equipment covered includes RCA's line of "Fleetfone" and "Carfone" transmitters and receivers for station locations and a portable 15-watt AC Carfone station unit.

The new brochures are: RCA "Fleetfone" station equipment, a 16-page, illustrated booklet describing the RCA Type CT-10A 70-watt and the Type CT-11A 250-watt "Fleetfone" transmitters and the companion Type CR-15A receiver.

(45) Pressure Vessels

The American Car and Foundry Company, Milton, Pennsylvania, has published a 14-page two color bulletin concerning its welded pressure vessels. It is most concerned with tanks for storage under pressure. Included is an illustrated section containing tables and diagrams of the ACF standard storage tanks for liquid propane, ranging from 18,000 to 30,000 gal capacity. Another section deals with truck tanks for bulk delivery of liquid propane. The last section lists factors to consider in a tank installation.

(46) Alkylation Process

New developments in alkylation, basic process in the production of high octane aviation fuel, are discussed in Kelloggram No. 5 (1950), just published by The M. W. Kellogg Company, Jersey City, New Jersey. The booklet also discusses the use of alkylation as a method of raising octanes to meet the challenge of the high compression automobile engine, a field in which this process has very promising possibilities, according to Kellogg.

(47) Tamping Rollers

A new catalog, Bulletin No. 892, on its line of sheepsfoot tamping rollers has been released by The Baker Manufacturing Company of Springfield, Illinois, manufacturer of earth-moving equipment. The booklet describes the specially Baker-designed feet, shaped to compact soil without disturbing it on pullout. The Baker rollers are made in single, double, and triple drum models, with tandem hitches available for 3-2-1 or 2-1 operation. Some of the features include spring-cushioned draw bar, universal clevis, forged tampers, replaceable toes, box section all around with double-reinforced corners, shear type cleaners at front and rear, the company reported.

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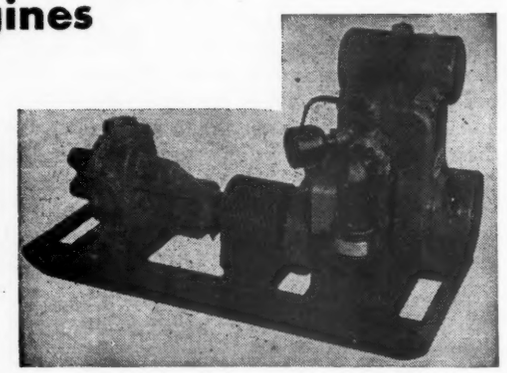

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(48) Services Report

An up-to-date report on services offered plus a brief history of the company is included in a new 12-page multicolored booklet, by Chemical Process Company, division of the Independent-Eastern Torpedo Company, Breckenridge, Texas. It describes acidization of wells by the "Permeter," which measures the relative permeability of exposed sections in a well by determining amount of fluid each permeable zone will receive under a given pressure. Latest types of equipment used in acidizing process are discussed in detail.

(49) Stock Catalog

Boston Gear Works, Quincy, Massachusetts, announces that a new edition, No. 55, of the complete Boston Gear catalog has just come off the presses. Catalog No. 55 contains much information on new stock Boston Gear items together with application, selection, and ready reference data that has not appeared in previous editions. It also includes all of the product and engineering information in quick reference form. It lists over 100 product groups, including spur, miter, bevel, and worm gears, roller chain, sprockets, ratiomotors, ball bearings, couplings and pulleys—over 4,500 stock items. It provides engineering data, formulas, horsepower rating charts, reference tables and selection charts to enable anyone, even without technical training, to figure the correct power drive and select the right equipment for mechanical power transmission.

(50) Valves, Fittings, Flanges

Henry Vogt Machine Company, Louisville, Kentucky has published its 70th anniversary edition of the company catalog. The 400-page catalog includes new and improved drop forged steel valves and fittings for every modern piping need at high and low pressures and temperatures. A refrigeration section is included in the back of the book. The book contains materials specifications for all the different items the company manufactures, including chemical and physical specifications. A complete cross-section of a wide selection of valves can be found in the book. Pictures and descriptions of remote control devices take up two pages in the new catalog.

One section devoted to pressure-temperature service ratings for carbon steel, flanged valves, flanged fittings, flanges, and detailed tables on other equipment is included. Many data are contained in standards tables, as thread standards and basic dimensions of American standard taper pipe thread. A thumb index is placed in the center of the book, to facilitate looking up any section in the book. Three indices in the back of the book are a contents index, primary service pressure ratings index, and numerical index.

Henry Vogt Machinery manufactures drop forged steel valves, fittings and flanges, oil refinery and chemical plant equipment, water tube and tubular boilers, ice and refrigerating machinery, heat exchangers.

(51) Pipe Line Tractor

The "Caterpillar" Offset D8 Pipeline Tractor is the title of a new illustrated specifications booklet just released by Caterpillar Tractor Company, Peoria 8, Illinois. It gives specifications for the tractor and engine, for the Trackson MDW8 pipe layer, and for the Caterpillar No. 46 hydraulic control arranged for use with the pipe layer. Also included are travel speeds, lifting capacities as they vary with the overhang of the pipe layer, and details on the offset track arrangement and the No. 46 hydraulic control.

(52) Crawler Tractors

Two 16-page catalogs, each telling the story of a new A-C crawler tractor have just been issued by Allis-Chalmers Tractor Division, Milwaukee, Wisconsin. One describes the Model HD-9, which weighs 18,500 lb and develops 70.0 drawbar horsepower. The other covers the Model HD-15, which weighs 27,500 lb and develops 102.0 hp at the drawbar. Each catalog utilizes double-page spreads to discuss major features of the tractor, such as unit construction, General Motors 2-cycle diesel power, the complete power train, frame and track design, simplicity of operation and ease of maintenance, including 1000-hour lubrication.

(53) Research, Analysis

The acceleration of research through the use of industrial and related instruments and apparatus is the subject of an 8½ by 11, 84-page book just published by Brown Instruments Division of Minneapolis-Honeywell Regulator Company, Philadelphia, Pennsylvania. The book describes, for what is believed the first time, many types of equipment which, alone or in combination with other apparatus, are being used in research and analytical studies. The book is replete with known research and analytical instrumentation uses. Under the heading of Analytical Apparatus, it details the robotized polarograph, titrator, and still applications and describes various types of spectrometers.

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Books you may want

World Geography of Petroleum, *edited by Wallace E. Pratt and Dorothy Good, published by The Princeton University Press, Princeton, New Jersey. Pages, 404. Price, $7.50.*

This book is divided into 4 parts explaining the subject of world geography of petroleum. In Part 1 the origins of petroleum are described together with reasons why it is found only in certain regions. The organization of the oil industry, including drilling methods, transport facilities and distribution systems are found in Part 2. Part 3 describes the productive regions and the problems set for the oil industry by geology, topography, and many other phases. Part 4 has a central theme of the geography use, where the world's oil goes, how the rates and kinds of production and consumption compare among the nations. The text is supplemented with 50 maps, 11 diagrams, and 98 photographs.

A.S.T.M. Standards on Petroleum Products and Lubricants, *published by American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa. Pages, 780. Price, paper cover $5.50, cloth cover $6.15.*

Prepared by committee D-2 on petroleum products and lubricants, this edition gives standards of the ASTM including 112 test methods, 8 specifications, 3 lists of definitions relating to petroleum, and 2 tentative recommended practices for the purchase of mineral oil for use in transformers and in oil circuit breakers. There are also groups of widely used standards covering broad classifications of petroleum products.

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Industrial and Safety Problems of Nuclear Technology, *edited by Morris H. Shamos and Sidney G. Roth. Harper and Brothers Publishers, 49 East 33rd Street, New York 16, New York. Pages, 367. Price, $4.*

The special technological problems and dangers peculiar to the development of atomic power are here discussed by Gordon Dean, chairman of the U. S. Atomic Energy Commission and 19 other leaders in the fields of industrial development, nuclear research, radiation medicine, and casualty insurance. The book is an outgrowth of a recent conference sponsored by the Atomic Energy Commission and New York University's Division of General Education. In brief, the book is devoted to the non-military applications of atomic energy to industry, agriculture, and medicine.

Fifteenth Annual Petroleum Number 1950, *published by Mines Magazine, 734 Cooper Building, Denver, Colorado. Pages, 148. Price, $2.*

Petroleum edition of Mines Magazine, official organ of the Colorado School of Mines Alumni Association, covers production and refinery information supplied by top men in the industry. The magazine contains more than 150 tables, maps, and illustrations, and some 22 articles on drilling, refining, photogeology, research, exploration, and other subjects of interest in the petroleum industry.

Distillation Equilibrium Data, *by Ju Chin Chu, published by Reinhold Publishing Corporation, 330 W. 42nd St., New York, N. Y. Pages, 304. Price, $6.*

The vapor-liquid equilibrium data here provide a reference in the design, performance prediction, and operating characteristics of distillation equipment in the chemical and petroleum industries. The work is divided into three parts —binary, ternary, and multi-component systems, totaling 176. At the end of the book is a formula index. Original references for all data are given.

Utilization of Texas Serpentine, *by Virgil E. Barnes, D. A. Shock, and W. A. Cunningham, published by the University of Texas, Bureau of Economic Geology. Pages, 52. Price, 60 cents.*

A paper relating to the possible commercial uses of Texas mineral commodity, this publication contains 19 text figures, 17 tables, and a geologic map of the serpentine mass at Coal Creek, which is in Blanco and Gillespie counties. A discussion of the mineral and chemical composition and crystal structure of the serpentine minerals is given, as well as possible uses for producing compounds to be used in making magnesium metals and compounds.

The Institute of Petroleum Electrical Code, Part I, *published by The Institute of Petroleum, Manson House, 26, Portland Place, London, W.I. Pages, 94. Price, 26s.*

This code is Part I of a "Model Code of Safety Practice in the Petroleum Industry." Other parts are now in preparation. Compiled by a special committee of the Institute of Petroleum, it represents the present considered views of the Institute after receiving comments on the first (1946) edition. The Code lists regulations and legislation of both America and United Kingdom on the subject.

Cleaning Petroleum Storage Tanks, Section B—Gasoline Tanks, *published by American Petroleum Institute, 50 West 50th Street, New York 20, N. Y. Pages, 12. Price, 75 cents.*

The purpose of this manual is to help prevent accidents in cleaning storage tanks that have contained gasoline. The booklet, illustrated with sketches and drawings, sets out simply a fund of information valuable to supervisors and foremen who are responsible for the safety of men and equipment in the cleaning of storage tanks.